GEOLOGICAL SURVEY BRANCH
DEPARTMENT OF MINES AND ENERGY
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

GEOLOGY OF THE EASTERN PART OF THE GANDER (NTS 2D/15) AND WESTERN PART OF THE GAMBO (NTS 2D/16) MAP AREAS, NEWFOUNDLAND

P.P. O'Neill and S.P. Colman-Sadd

Report 93-2

St. John's, Newfoundland
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COVER

Burned-over area exposing white-weathering granite boulders (Hunts Ponds Granite) in a view looking south across Gillingham Pond, south of Gander Lake (photo courtesy of R.F. Blackwood).

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ABSTRACT

The map area occupies those parts of the Gander and Gambo NTS map areas that have not been previously mapped at the 1:50 000 scale. The present mapping overlaps sufficiently with the earlier mapping to provide continuity and a comparison of stratigraphic nomenclature. The area encompasses the eastern two-thirds of Gander Lake, and country both north and south of the lake and eastward to Freshwater Bay.

Most of the map area lies within the Gander Lake Subzone of the Gander Zone and includes the original type section of the Gander Group. The group is divided into the Jonathan's Pond and Indian Bay Big Pond formations. The Jonathan's Pond Formation consists mainly of psammite and quartzite interbedded with pelite. Its age is not known directly, but it is inferred to be Cambrian and Early Ordovician. The Indian Bay Big Pond Formation is thought to overlie the Jonathan's Pond Formation conformably in the Weir's Pond map area and that relationship may also exist in the present map area. The age of the Indian Bay Big Pond Formation is presumed to be Early Ordovician (Arenig–Llanvirn) on the basis of fossils in the Weir's Pond area. It has two outcrop areas: the northern one includes conglomerate, sandstone and siltstone, and the southern one, near Gander Lake, is principally psammite, pelite and calc-silicate.

With the exception of two exposures of mafic and ultramafic rocks in the Gander Zone, ophiolitic rocks are restricted to the Gander River Complex. The complex has been mapped previously and this report does not give a detailed description. Ultramafic rocks, gabbro, plagiogranite, diabase and mafic volcanic rocks are all included within the complex, which is assumed to be Early Ordovician or older. The Gander River Complex forms the eastern margin of the Exploits Subzone of the Dunnage Zone and is in tectonic contact with the Gander Group of the Gander Zone. Also included in the Exploits Subzone, are rocks of the Weir's Pond Formation, a unit of the Davidsville Group. This formation consists of sandstone, conglomerate, shale and calcareous lenses, and contains fossils that range in age from Arenig to Caradoc. At one locality on Gander Lake, the formation is unconformable on the Gander River Complex.

The Gander Group has been intruded by three suites of plutonic igneous rocks: (i) small intrusions of granite and gabbro located in the eastern part of the map area in the Wing Pond Shear Zone, (ii) scattered garnet–biotite–muscovite–granite intrusions related to the Hunts Ponds Granite, and (iii) the posttectonic, megacrystic Gander Lake Granite.

The main deformation in the Davidsville Group and the Gander River Complex was the first deformation of these rocks, whereas the main foliation in the Gander Group is a second-generation structure. In the west, this foliation has moderate dips to the west and strikes northward. The strike is deflected northeastward at the Soulis Pond Metamorphic Zone and steepens as the Wing Pond Shear Zone is approached. The high-strain foliation in the Wing Pond Shear Zone, at the eastern edge of the map area, is thought to be the result of the third deformation of the Gander Group. A major displacement of the Gander River Complex and metamorphic facies across Gander Lake is attributed to a fault that is not exposed, but is presumed to have formed relatively late in the development of the area.

The area has been affected by both regional and contact metamorphism. Regional metamorphism in the west is centred around the Hunts Ponds Granite as a low-pressure, regional aureole. The isograds are superimposed across the tectonic Dunnage–Gander zone boundary. At the eastern edge of the area, a linear belt of elevated low- to medium-pressure, regional metamorphism coincides with the Wing Pond Shear Zone. A contact metamorphic aureole around the Gander Lake Granite overprints both of the regional metamorphic highs. North of Gander Lake, the metamorphic grade is relatively low, except in the Wing Pond Shear Zone, and it is not clear how areas of moderately high grade relate to the overall pattern of metamorphism. In particular, the origin of the Soulis Pond Metamorphic Zone is problematic.

$^{40}Ar/^{39}Ar$ geochronology indicates that metamorphic cooling in the Wing Pond Shear Zone was Early to Middle Silurian (ca. 429 Ma) and that the regional metamorphic aureole of the Hunts Ponds Granite cooled in the Early Devonian (ca. 389 Ma).

Mineral exploration in the area has been mainly directed at the base-metal and gold potential of the Gander River Complex. However, in recent years, there has also been some exploration for gold within the Gander Group and new occurrences with elevated values of various metals have been discovered during the course of mapping. Dimension stone, bedrock aggregate and surficial aggregate are other commodities having significant potential.

INTRODUCTION

This report presents the results of geological field mapping completed in 1989 and 1990, and of laboratory research on the petrology, petrography and $^{40}Ar/^{39}Ar$ geochronology of samples collected during the mapping. The regions studied were the eastern part of NTS 2D/15 (Gander Lake map area) and the western part of NTS 2D/16 (Gambo map area) (Figure 1). Some parts of this report have been published previously in the Geological Survey Branch's Current Research series (see O'Neill, 1990 and 1991a).

REGIONAL GEOGRAPHY

Much of the northern part of the study area is accessible from the Trans-Canada and Gander Bay highways (Routes 1 and 330), by four-wheel-drive vehicle along several logging roads, and by boat from Soulis Pond, Home Pond, Gander Lake and Square Pond. The central and southern parts of the area can be reached by four-wheel-drive and all-terrain vehicles from logging roads that connect with the Trans-Canada Highway near Gambo, and by boat from Rodney Pond, Gander Lake and Square Pond. Both fixed-wing and rotary aircraft are available at Gander, in the centre of the study area.

North of Gander Lake, the region is dominated by a low-lying plateau, which is flat around Gander but more undulating to the east and west. The flat topography reflects the subhorizontal nature of planar fabrics in the bedrock. In the northeast, Home Pond, Wing Pond, Gull Pond and Soulis Pond occupy topographic depressions that dissect the plateau and drain eastward or southward. North of Gander, drainage is poor and marshes and swamps are extensive.

The topography south of Gander Lake is also characterized by a plateau, containing several ponds, of which the largest is Rodney Pond, and by Hunt's Brook, Joe's Brook, Fifteen Mile Brook, and the unnamed brooks that drain eastward from Rodney Pond. The latter system eventually empties into Freshwater Bay through Middle Brook. The gently undulating topography, with local elevations rising to between 200 and 250 m, reflects both the absence of a strong structural grain in the underlying bedrock and the presence of a boulder-rich till.

Much of the north shoreline of Gander Lake is characterized by a sharp change in elevation from 25 m on the shore to about 110 m on the plateau. Where a brook drains from Soulis Pond into Gander Lake, however, this escarpment trends away from the lake toward the northeast, passing west of Benton and controlling the orientations of Soulis Pond and Soulis Brook. A major bend in the trend of Gander Lake occurs at the intersection with the escarpment, but south of the lake there is no physiographic expression of this or any other topographic lineament.

The most rugged topography occurs on the east side of Square Pond, where the land rises to approximately 200 m and falls off steeply toward Gambo Brook and Freshwater Bay.

Bedrock exposure is generally poor in the upland parts of the map area and boulder fields are extensive where the Gander Lake Granite outcrops. Some of the best exposures between Gander and Square Pond are the result of new highway construction. However, there is good natural exposure of both the granite and the Gander Group along Gander Lake and in the rugged country northeast of Square Pond.

PREVIOUS WORK

The earliest geological work in the Gander Lake area was done by Alexander Murray in 1874 (Murray and Howley, 1881), who noted that schists on the lake shore resembled slates of presumed Late Silurian age near Gander Bay. On this evidence, he assigned these metasedimentary rocks to the Silurian, but proposed a Precambrian age for the granitoid bodies to the south and east of the lake. He also described the northeast-trending belt of mafic and ultramafic rocks that occurs on both sides of Gander Lake and, in this report, is referred to as the Gander River Complex (O'Neill and Blackwood, 1989). Snelgrove (1933, 1934) assessed the chromite occurrences in the ultramafic rocks for the Geological Survey of Newfoundland and re-examination of these in the 1940's, and again in 1951 and 1952, led to the publication of a map and report that documented most of the ultramafic bodies north and south of Gander Lake (Jenness, 1954). Twenhofel (1947) correlated the sequence of phyllite, slate and quartzite along Gander Lake, which he named the Gander Lake Series, with fossiliferous Silurian rocks east of Hamilton Sound; he thought that the Series lay unconformably on metasedimentary rocks farther east. Baird *et al.* (1951), who conducted one of the earliest regional mapping surveys in eastern Newfoundland, disagreed with Twenhofel's (1947) Silurian age for the Gander Lake Series and suggested that the rocks exposed beside the western part of Gander Lake are Ordovician.

Jenness (1958) changed the Gander Lake Series of Twenhofel to group status and assigned it to the Middle Ordovician, based on graptolite and brachiopod faunas. He later subdivided the Gander Lake Group into conformable lower, middle and upper units (Jenness, 1963). The middle unit consisted of sedimentary and volcanic rocks, but also included mafic and ultramafic plutonic igneous rocks of the Gander River Complex (then called the Gander River ultrabasic belt, Jenness, 1958), for which he provided the first detailed descriptions (Jenness, 1954, 1958). The Gander Lake Group was later redefined by Kennedy and McGonigal (1972) so that it consisted of only the lower arenaceous unit of Jenness (1963), and a new term, the Davidsville Group, was proposed for the sedimentary rocks of the fossiliferous middle and upper units.

The geology of the area immediately north and south of Gander Lake was the subject of an M.Sc. thesis by McGonigal (1973). He outlined two contrasting geological terrains, a metasedimentary terrain (the Gander Lake Group, which he

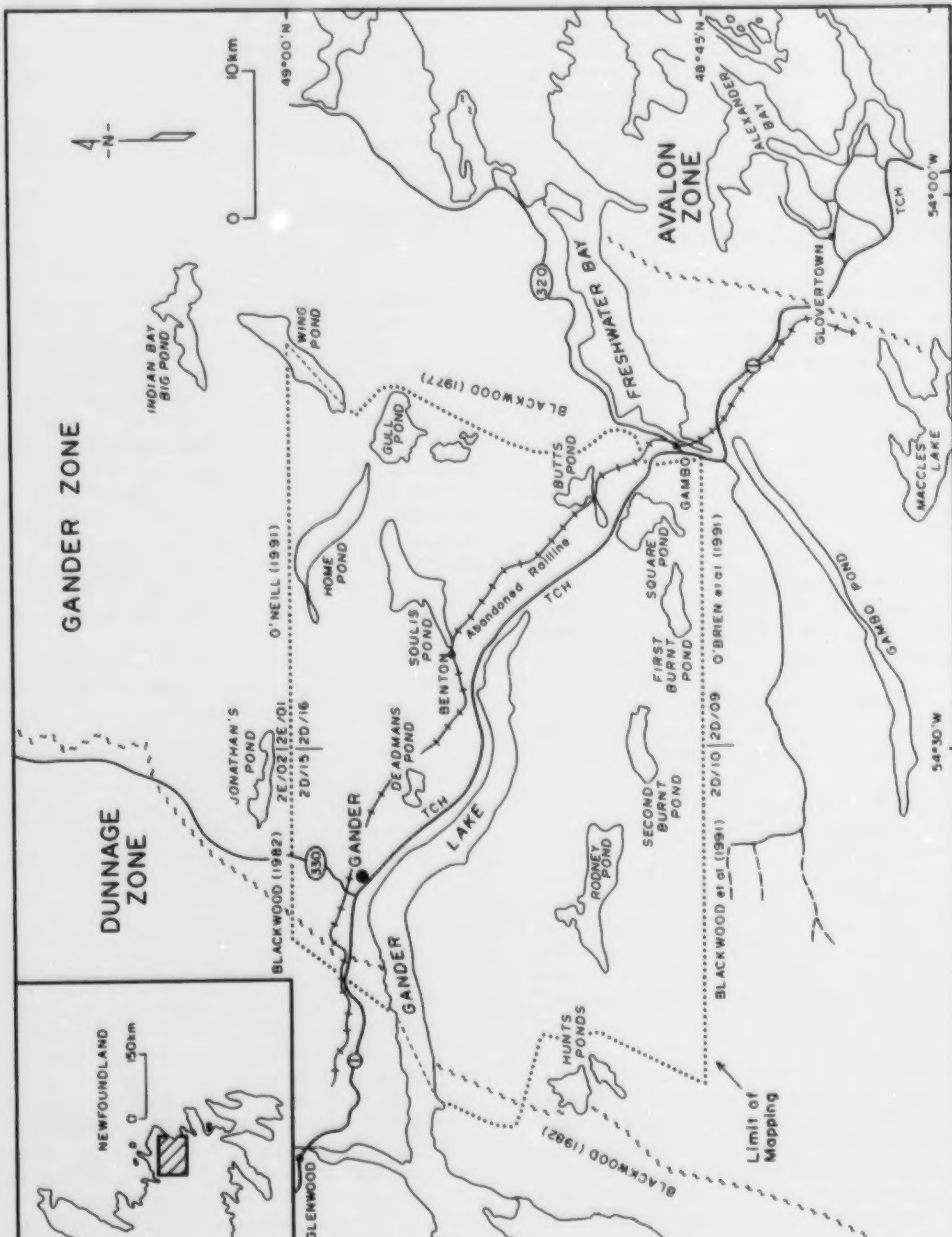


Figure 1. *Location map, showing limit of mapping.*

renamed the Gander Group) and a sedimentary and volcanic terrain (the Davidsville Group). A 'mixed member' of the Gander Group, comprising psammite, calcareous mica schist, graphitic mica schist and impure marble was structurally intercalated with components of the Gander River ultrabasic belt. A critical relationship in the ultrabasic belt was described by Kennedy (1975) from the north shore of Gander Lake, where conglomerate that he assigned to the Davidsville Group unconformably overlies serpentinized ultramafic rock.

Blackwood (1980), working both north and south of Gander Lake, redefined the Gander River ultrabasic belt to include volcanic as well as intrusive rocks. He excluded from the Gander Group sedimentary rocks that are structurally intercalated with the igneous rocks south of Gander Lake, and placed them in the Davidsville Group.

Stratigraphic nomenclature for the area was revised by O'Neill and Blackwood (1989) to incorporate new information gained during the previous decade of mapping. The Gander River ultrabasic belt was given a formal name, the Gander River Complex, which corresponds in style to names given to other ophiolitic complexes in Newfoundland, and both the Gander and Davidsville groups were subdivided into formations. The revised nomenclature is used in this report.

The granite intrusions that intrude the Gander Group south of Gander Lake were sampled by Strong *et al.* (1974) during a regional survey of eastern Newfoundland granitoid rocks; the part of this survey that included the granites in the present map area formed the basis of an M.Sc. thesis by Dickson (1974). Thirty-seven samples were taken from the Gander Lake Granite and 11 from the Hunts Ponds Granite (Gander Lake West granite). These were analyzed for major elements and a suite of fourteen trace elements. Tungsten mineralization was reported from the Hunts Ponds Granite and fluorite from the Gander Lake Granite. Some of the samples were reanalyzed for uranium by Davenport (1978), who noted anomalously high uranium (up to 19.4 ppm) in the northeast corner of the Gander Lake Granite. Preliminary isotopic work on eastern Newfoundland granitoid rocks has given an ϵ_{Nd} value of -3 and $\delta^{18}O$ value of 10 for a sample of the Gander Lake Granite, indicating the likely assimilation of Gander Group metasedimentary rocks by the magma (Fryer *et al.*, 1992).

The Quaternary geology of the western part of the area (NTS 2D/15) has been described by Vanderveer and Taylor (1987) and Batterson and Vatcher (1991), and maps showing landforms and ice-flow indicators have been published at the 1:50 000 scale by Batterson (1991) and Batterson *et al.* (1991). Two ice-flow events can be clearly recognized, the first eastward and the second north to north-northeastward. Much of the area is covered by diamictons, which generally have characteristics consistent with an origin as subglacial meltout till. The diamictons are notably thicker south of Gander Lake than in the north, where there are numerous bedrock exposures. In the eastern part of the area (NTS 2D/16), a prominent Quaternary feature is a large glaciofluvial outwash channel that extends from the southeast end of Gander Lake to Butts Pond (Environmental Geology Section,1983 a,b, NTS Maps 2D/16 to 22).

A lake-sediment geochemical survey was conducted across all of the NTS 2D area by the Newfoundland Department of Mines and Energy in 1980 (Butler and Davenport, 1981). The original element suite was added to, in a subsequent publication (Davenport *et al.*, 1988), which included, in particular, analyses for gold.

Airborne aeromagnetic maps have been published for the area by the Geological Survey of Canada (1968a, b). The original data has been digitized and released on computer disk by the Newfoundland Department of Mines and Energy (Kilfoil and Bruce, 1990).

Work by the mineral-exploration industry is reviewed in the section on economic geology (see below).

REGIONAL RELATIONSHIPS

The map area is underlain by three main geological units, the Gander and Davidsville groups and the Gander River Complex, as well as several younger granite intrusions. The Gander River Complex (O'Neill and Blackwood, 1989) and the Davidsville Group (Kennedy and McGonigal, 1972) form the eastern margin of the Exploits Subzone of the Dunnage Zone (Williams *et al.*, 1988). The Gander Group (McGonigal, 1973), which underlies most of the map area, is the most extensive unit in the Gander Lake Subzone of the Gander Zone (Figure 2).

The Gander Group was divided into the Jonathan's Pond and Indian Bay Big Pond formations by O'Neill and Blackwood (1989; Table 1). The Jonathan's Pond Formation consists of a monotonous sequence of interbedded quartz-rich sandstone and shale, and metamorphosed equivalents. It underlies most of the Gander Lake Subzone and is tentatively correlated with the Spruce Brook Formation of the Mount Cormack Subzone (Colman-Sadd, 1985a) and similar rocks in the Meelpaeg Subzone (Colman-Sadd, 1985b, 1988). The age of the formation is not known directly, but is inferred to be no older than Cambrian on the basis of dated detrital zircon (O'Neill, 1991b).

The overlying Indian Bay Big Pond Formation, which contains Arenig–Llanvirn fossils in the Weir's Pond area (NTS 2E/1) (Wonderley and Neuman, 1984), is much more restricted in distribution, and a change in depositional environment is indicated by the appearance of black shale, chert and both mafic and intermediate volcanic rocks (O'Neill, 1991b). Although the Indian Bay Big Pond Formation is conformable on the Jonathan's Pond Formation and is included in the Gander Group, it resembles rocks containing a similar late Arenig–early Llanvirn fauna that are included in the Davidsville Group (McKerrow and Cocks, 1977; Boyce *et al.*, 1988). Because of this, Williams and Piasecki (1990) and Colman-Sadd *et al.* (1992) have considered it to be part of an overlap sequence deposited after

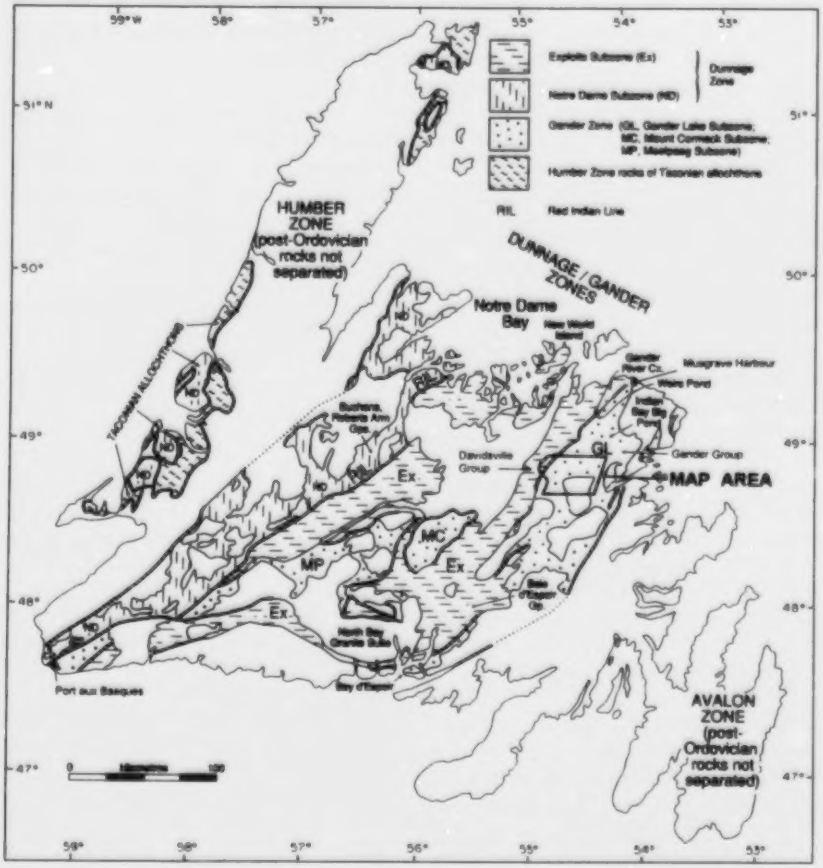


Figure 2. *Distribution and subdivision of the Dunnage and Gander zones in Newfoundland (simplified from Colman-Sadd* et al., *1990). The NTS 2D/15, 16 map area is outlined.*

emplacement of the Gander River Complex onto the Gander Zone.

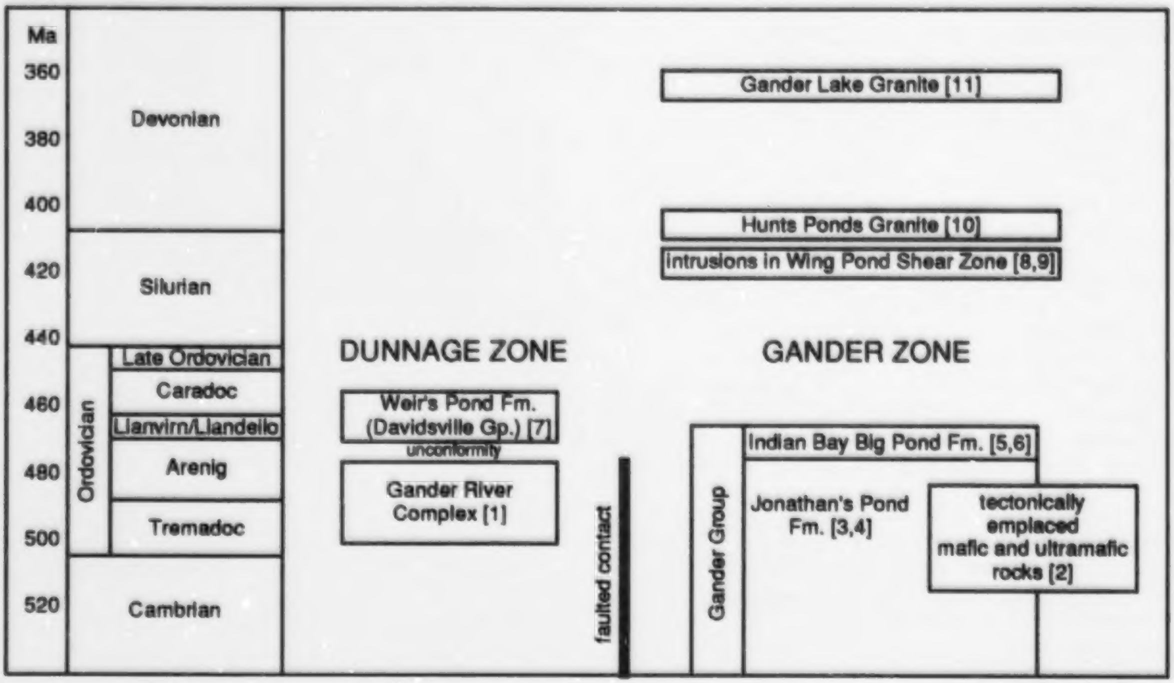
The Gander Group passes gradationally eastward into amphibolite-facies metasedimentary rocks, and is interpreted to be the protolith of at least part of the Hare Bay Gneiss (Blackwood, 1978). In the eastern part of the map area, the Gander Group is cut by a major structural feature, the Wing Pond Shear Zone. This is a zone of high strain and elevated metamorphism that affects the Jonathan's Pond Formation, and may also affect rocks of the Indian Bay Big Pond Formation and other unrecognized units. Despite its structural and metamorphic prominence, the zone does not appear to separate areas of differing geological development.

The Gander River Complex is an ophiolitic assemblage of ultramafic, mafic and felsic igneous rocks. It marks the boundary between the Davidsville Group in the west and the Gander Group in the east, and can be traced from the northeast coast of the Island into central Newfoundland near Middle Ridge. From limited exposure, the contact with the Gander Group is inferred to be tectonic (Blackwood, 1982) and a zone of ductile shearing is exposed on the north shore of Gander Lake (Williams *et al.*, 1991). The contact with the Davidsville Group, however, although generally faulted, is interpreted to be an unconformity north of Gander Lake, where conglomerate of the Davidsville Group overlies serpentinized ultramafic rock (Kennedy, 1975). Outside the map area, the Gander River Complex is locally missing from the Dunnage–Gander zone boundary and the Davidsville and Gander groups are in direct contact. In these locations, there has been considerable dispute as to whether the zone boundary is stratigraphic or structural, but recent work indicates that it is a shear zone (Williams *et al.*, 1991).

The age of the Gander River Complex is unknown, but a poorly defined $^{40}Ar/^{39}Ar$ spectrum (D. Lux, *in* O'Neill, 1991b) suggests a general correspondence with other age data from Exploits Subzone ophiolites. These other data primarily consist of a U–Pb age of 494^{+1}_{-2} Ma on the Pipestone Pond Complex (Dunning and Krogh, 1985) and a late Arenig fossil locality in shale overlying the Coy Pond Complex (Williams *et al.*, 1992). Together the available data support an Early Ordovician (Tremadoc) age for the ophiolites.

The Davidsville Group consists of the Weir's Pond, Hunt's Cove and Outflow formations (O'Neill and Blackwood, 1989), of which only the Weir's Pond Formation is represented

Table 1. Table of formations. Time scale from Palmer (1983) and Tucker *et al.* (1990); unit numbers are shown in square brackets



in the map area. It is a varied assemblage of limestone, sandstone, shale and conglomerate that is structurally imbricated with the Gander River Complex and contains faunas ranging in age from late Arenig–early Llanvirn to Caradoc. Different parts of the Weir's Pond Formation resemble units that are widely dispersed through the Exploits Subzone and the Gander Zone. The similarity of the late Arenig–early Llanvirn part of the formation to the Indian Bay Big Pond Formation has been noted above; these rocks are also similar to the fossiliferous unit of the same age at Virgin Arm on New World Island (Neuman, 1976; Boyce *et al.*, 1988). The Llanvirn–Llandeilo limestone occurrence at Weir's Pond itself (Stouge, 1980; O'Neill, 1991b) is one of many limestone localities of this age, of which the best known is the Cobb's Arm Limestone on New World Island (Bergström *et al.*, 1974), and the black shales containing Caradocian graptolites are correlatives of the Lawrence Harbour Formation that is widespread across central Newfoundland (Williams, 1991). The western formations of the Davidsville Group, consisting mainly of turbidites, have a more consistent expression and can be traced across the island and correlated with units of the Baie d'Espoir Group (O'Neill and Blackwood, 1989). The slates of the Hunt's Cove Formation correspond to the St. Josephs Cove Formation (Colman-Sadd, 1976; Dickson, 1987) and the sandstone, conglomerate and slate of the Outflow Formation with the North Steady Pond Formation (Colman-Sadd, 1980).

Small bodies of a garnetiferous, muscovite granite, which occur in the western part of the map area and include the Hunts Ponds Granite, are similar to granitic intrusions that are common throughout the Gander Zone, from the northeast coast at Musgrave Harbour (Ragged Harbour Complex, Currie *et al.*, 1979) to the south coast at Bay d'Espoir (Dolland Bight Granite, Elias and Strong, 1982) and Port aux Basques (Rose Blanche Granite, Brown, 1976). Several of these intrusions also cut rocks of the Exploits Subzone. Most are considered to be Silurian or Early Devonian on the basis of U–Pb, $^{40}Ar/^{39}Ar$ and Rb–Sr dating, although one granite of this type, the Through Hill Granite, is known to be Middle Ordovician (Colman-Sadd *et al.*, 1992). Dating of the Middle Ridge Granite immediately to the south (Bell *et al.*, 1977; Tucker, 1990) and of the Ocean Pond Granite to the north (O'Neill, 1991b) strongly suggests a Silurian age for the Hunts Ponds Granite and this is supported by $^{40}Ar/^{39}Ar$ data published in this report. The Hunts Ponds Granite is entirely restricted to the Gander Zone and it is associated with a low-pressure, regional metamorphic aureole in rocks of the Jonathan's Pond Formation (Unit 3).

The Gander Lake Granite, which intrudes the Gander Group south of Gander Lake, is one of several posttectonic, biotite, megacrystic granites in the Gander Lake Subzone. The granite is restricted to the Gander Zone but others, most notably the Ackley Granite Suite (Dickson, 1983) in southern Newfoundland, intrude the Exploits Subzone and the Avalon Zone as well. No precise U–Pb ages are available for any of these granites, but a large number of determinations by a variety of other methods suggest that the intrusions were emplaced in the Middle or Late Devonian, or possibly even

in the Early Carboniferous (Mandville, 1991). The Gander Lake Granite is surrounded by a contact metamorphic aureole, up to 2 km wide, which affects rocks of the Jonathan's Pond and Indian Bay Big Pond formations.

DESCRIPTION OF UNITS

The primary focus of mapping has been the Gander Group and intrusions into it. Both the Gander River Complex and the Davidsville Group have been mapped previously by Blackwood (1982) and were examined principally to provide continuity with work carried out in the Weir's Pond area (O'Neill, 1987, 1991b; O'Neill and Knight, 1988). Thus, descriptions of the Gander River Complex refer only to parts that are close to the contact with the Gander Group, and those of the Davidsville Group are from exposures on the south shore of Gander Lake, which belong to the Weir's Pond Formation (as defined by O'Neill and Blackwood, 1989 and O'Neill, 1991b). Ultramafic rocks from elsewhere in the map area are considered to be related to the Gander River Complex because of their composition, but there is no stratigraphic or structural evidence to support this inference.

OPHIOLITIC ROCKS

Gander River Complex (Unit 1)

Definition and Distribution

The name, Gander River Complex, was proposed by O'Neill and Blackwood (1989) and formalized by O'Neill (1991b). The complex includes ultramafic rocks, mafic plutonic and extrusive rocks, and plagiogranite, which collectively form a discontinuous ophiolite belt at or close to the boundary between the Gander Lake and Exploits subzones. In the map area, most exposures of the Gander River Complex are north of Gander Lake; the few that are south of the lake, where the Complex is significantly narrower and displaced westward about 6 km, are widely dispersed because of the extensive drift cover.

Contact Relationships and Age

In most places, the Gander River Complex is in tectonic contact with both the Gander and Davidsville groups. However, just east of Little Harbour on the north side of Gander Lake, conglomerate of the Davidsville Group overlies serpentinized ultramafic rock. This relationship has been interpreted as an unconformity (Kennedy, 1975), although the actual contact is now strongly foliated and may be a high-strain zone. North of Gander Lake, the contact with the Gander Group is marked by a lineament along most of its length, but exposures of the actual contact were not found. South of Gander Lake, the boundaries defined by mapping do not coincide with any airphoto lineaments.

The age of the Gander River Complex has not been determined directly because all attempts at radiometric dating either have failed to separate suitable minerals or have produced ambiguous results (O'Neill, 1991b). Minimum ages, however, can be inferred from stratigraphic relationships. The Complex is certainly no younger than Llanvirn–Llandeilo limestone that is unconformable on altered ultramafic rock at Weir's Pond, to the north of the map area (O'Neill, 1991b). An older unconformable relationship is inferred from sediments containing a late Arenig–early Llanvirn fauna a few kilometres to the southwest of this locality (Boyce *et al.*, 1988); abundant chromite detritus in the sediments reveals that the Complex was being eroded at this time (O'Neill, 1991b). A similar relationship is inferred from a late Arenig–early Llanvirn fossil locality on the north shore of Gander Lake (McKerrow and Cocks, 1977; Blackwood, 1982).

Lithology

North of Gander Lake, the Gander River Complex is lithologically diverse, but is undivided on Map 93-15 (back pocket) because of the complex distribution of rock types. Fresh pyroxenite is preserved in some places and is generally massive. However, most of the ultramafic rocks are altered to serpentine ± carbonate ± talc assemblages. The altered rocks are characterized by a steep foliation, which locally is partitioned into higher strain zones, several metres wide, separated by less intensely foliated areas. In places, the foliated ultramafic rock is richly pyritiferous. Intensely foliated and altered ultramafic rock that weathers a distinct purple occurs in one locality on the Trans-Canada Highway, west of Gander. At another exposure, serpentinized ultramafic rocks were intruded by diabase dykes, which subsequently were also deformed.

White-weathering ultramafic rocks (subunit 1a), exposed on the south shore of Gander Lake, are composed of talc–carbonate mineral assemblages and locally contain coarse-grained rusty siderite crystals. These rocks are separated from the westernmost exposures of the Gander Group by a 2-m exposure gap. Southwest of Gillinghams Pond, altered ultramafic rock (subunit 1b), which weathers mottled bluish-grey to orange and black, contains relict pyroxene crystals and was probably derived from pyroxenite. It lies immediately adjacent to black shale of the Davidsville Group (Unit 7), but the actual contact between the two units is not exposed.

Pegmatitic gabbro north of Gander Lake is massive to moderately foliated, and medium to coarse grained. Some pyroxene-rich zones are present and, in one exposure, trondhjemite is associated with the gabbro; the trondhjemite is characterized by a high-strain foliation. Several outcrops of massive gabbro also occur on the south shore of the lake (subunit 1c), where they are locally pegmatitic and in places display a banding defined by alternating feldspar-rich and feldspar-poor layers.

Isolated exposures of strongly foliated mafic volcanic rock occur throughout the Gander River Complex. They are commonly chloritized and are cut by thin epidote and/or carbonate veins.

Petrography

The exposure of altered ultramafic rock on the Trans-Canada Highway (west of Gander) is composed mainly of calcite, opaque minerals and minor epidote. A high-strain foliation is defined principally by extreme stretching of the opaque grains and anastomoses around elliptical calcite-rich areas. The fabric is folded by late folds.

On the south shore of Gander Lake, talc defines the foliation in the talc–carbonate rocks (subunit la) and relict chromite grains are disseminated throughout the rock. The carbonate, which is coarse grained, has irregular grain boundaries, where it is in contact with talc, and the two minerals appear to be in disequilibrium. Locally, carbonate has overgrown the talc grains. The variety of the talc–carbonate rock that contains siderite crystals has very fine-grained opaque material concentrated in the centres of some carbonate grains and along grain boundaries.

The distinctly orange-weathered ultramafic rock southwest of Gillinghams Pond (subunit lb) consists predominantly of carbonate, along with minor intergrown tremolite. Other parts of the exposure are composed mainly of serpentine and minor amounts of chromite, with about 10 percent of the rock composed of relict pyroxene and associated abundant fine-grained opaque material. Crosscutting chlorite veins are foliated and discontinuous.

The gabbro is altered and contains up to 50 percent hornblende. The metamorphic mineral assemblages include green and blue-green hornblende, actinolite, chlorite, turbid brown feldspar, albite, prehnite, epidote and/or clinozoisite. Gabbro on the south shore of Gander Lake (subunit lc) also contains small amounts of biotite and quartz. The foliation is heterogeneous, and cataclastically foliated zones anastomose around low-strain zones. Very tight, relict folds occur in some foliated zones.

The mafic volcanic rocks consist of a metamorphic assemblage of quartz, chlorite, feldspar, titanite and carbonate. The strain is generally heterogeneous. Where a high-strain foliation is developed, it is defined by lenticles of polygonized quartz and recrystallized calcite up to 1 cm long, and by seams of fine-grained opaque material.

Other Mafic and Ultramafic Rocks (Unit 2)

Distribution, Contact Relationships and Age

Ultramafic rock that is spatially separate from the Gander River Complex is exposed at two places in the map area. One occurrence is 1 km west of Butts Pond on the old Canadian National railway line, and the second is in a road cutting beside the Trans-Canada Highway, northeast of Square Pond, where it is associated with fine-grained mafic rocks.

The ultramafic body on the railway line lies immediately west of an exposure of interbedded psammite, semipelite and pelite, but the contact is hidden so the nature of the relationship is unknown. However, on the Trans-Canada Highway, the contact between ultramafic rock and psammite and semipelite of the Jonathan's Pond Formation (Unit 3) is exposed and is clearly tectonic.

The ages of the ultramafic and associated mafic rocks are unknown, but by analogy with similar rock types in the Gander River Complex they are likely to be Early Ordovician or older. The two occurrences are located within the Wing Pond Shear Zone, which $^{40}Ar/^{39}Ar$ dating indicates is an Early Silurian structure. The final emplacement of these rocks is therefore likely to be of this age.

Lithology

The ultramafic rock on the old railway line is weathered to a mottled to streaky, bluish-grey and orange colour. It has a penetrative foliation that is parallel to the regional foliation in the Gander Group and to the foliation in the Wing Pond Shear Zone. In the adjacent exposure of metasedimentary rocks, there are distinctive green bands, several centimetres thick, of alternating chlorite-rich and green amphibole-rich layers. Because of their unusual composition and close physical relationship with the ultramafic rock, these bands may be genetically related to the ultramafic rocks. High strain in these rocks is indicated by ribbon quartz and suggests that the banding may have a tectonic origin.

The ultramafic rock on the Trans-Canada Highway is mottled on fresh surfaces with pale green and black patches. Locally, fibrous serpentine occurs in talc-rich parts. The rock has a poorly defined compositional layering of light and dark layers and is strongly foliated where it is cut by possible shear zones. The associated mafic rocks are dark green and medium to very fine grained; they are cut by numerous quartz veins.

Petrography

The ultramafic rock west of Butts Pond is completely altered to an assemblage of patchily distributed serpentine and talc, with minor carbonate, chlorite and magnetite. Talc is locally foliated and is overgrown by chlorite, and both talc and chlorite are enclosed in unfoliated serpentine.

The green micaceous rock, which is interbanded with nearby metasedimentary rocks on the railway line, is also internally banded. Assemblages of chlorite, clinozoisite and carbonate, associated with minor talc and muscovite pass gradationally into rock formed of carbonate and blue-green amphibole, containing minor biotite, muscovite and garnet; this rock type varies from carbonate dominated to hornblende dominated. An interbanded dark-green rock contains plagioclase, quartz and opaque material, having either biotite and a colourless amphibole or hornblende.

Ultramafic rock from the Trans-Canada Highway exposure is variably altered. The least altered component is coarse grained and composed mostly of colourless amphibole, probably tremolite, and relict pyroxene or olivine, which is partly replaced by serpentine, carbonate and talc. Elsewhere in the exposure, the rock consists mostly of carbonate, forming very fine-grained masses and dispersed coarse-grained anhedra, and has accessory chlorite and serpentine.

Mafic rock, associated with the ultramafic rock, contains about 65 percent green to pale-green hornblende, which forms scattered equant to subequant grains overgrowing a fine-grained, foliated hornblende matrix. Layers rich in quartz also contain plagioclase, biotite and hornblende.

GANDER GROUP

Jonathan's Pond Formation (Units 3 and 4)

Definition, Distribution and Division

The formation was formally named and defined in the Weir's Pond map area (NTS 2E/1), where it consists principally of psammite and semipelite forming two outcrop belts (O'Neill, 1991b). The western belt, between the Gander River Complex and the Indian Bay Big Pond Formation, extends southward to underlie most of the area described in this report. The eastern belt, which lies east of the Indian Bay Big Pond Formation, extends into the map area at Wing Pond and continues south toward Square Pond and Gambo, where it includes metamorphic rocks previously assigned to the Square Pond Gneiss (Blackwood, 1977). The two belts join east of Gull Pond at a break in the outcrop of the Indian Bay Big Pond Formation (Units 5 and 6), occupied by the Wing Pond Shear Zone. Equivalents of the Jonathan's Pond Formation have been mapped, but not formally defined, in the Carmanville area (NTS 2E/8) (Currie *et al.*, 1980), north of the Weir's Pond area, and southward to the Mount Sylvester area (NTS 2D/3) in central Newfoundland (Dickson, 1986).

Two units are recognized within the Jonathan's Pond Formation. Unit 3 constitutes the bulk of the formation and is dominated by psammite and semipelite. Unit 4 occurs adjacent to the Gander River Complex on the north side of Gander Lake and is distinguished by the presence of black shale interbeds; it corresponds with Unit 11 of O'Neill (1991b), which was similarly separated as a distinct facies within the Jonathan's Pond Formation in the Weir's Pond map area. The two units are in gradational contact with each other and their relative stratigraphic positions are unknown.

Within Unit 3, rocks that are above chlorite grade have developed under four different metamorphic regimes, which are described separately. These are the aureoles associated with the Hunts Ponds and Gander Lake granites respectively, the Soulis Pond Metamorphic Zone, and the Wing Pond Shear Zone.

Contact Relationships and Age

Unit 4 of the Jonathan's Pond Formation is in tectonic contact with the Gander River Complex and it is presumed that Unit 3 is also. This is especially likely south of Gander Lake, where Unit 4 is absent even though there is only a small exposure gap, and where the contact is marked by a zone of heterogeneous high strain (Goodwin and O'Neill, 1991). The Jonathan's Pond Formation is thought to be stratigraphically continuous with the Indian Bay Big Pond Formation in the Weir's Pond area (O'Neill, 1991b); it is likely that this relationship continues south into the map area, although there is insufficient exposure to verify it. Unit 3 of the Jonathan's Pond Formation is cut by sheets of both the Hunts Ponds and Gander Lake granites (Units 10 and 11), and is also intruded by gabbro and granite in the Wing Pond Shear Zone (Units 8 and 9).

The Jonathan's Pond Formation is presumed to be overlain by the Indian Bay Big Pond Formation (Units 5 and 6) and therefore is also presumed to be older than the late Arenig–early Llanvirn fauna contained in these rocks (O'Neill, 1991b). Titanite grains from the Jonathan's Pond Formation have be dated at about 540 Ma and are interpreted by T. Krogh (personal communication, cited by O'Neill, 1991b) as detrital, as is zircon dated at 550 Ma. These U–Pb ages place a probable lower limit on the age of the formation in the Early Cambrian.

Lithology: Unit 3–General

The Jonathan's Pond Formation is composed mainly of psammite, semipelite and pelite interbedded in various proportions and with varying bed thicknesses. Concordant mafic layers are common, and unseparated felsic igneous bodies occur locally.

The psammite is grey weathering, thin to thick bedded, and sedimentary structures are poorly preserved because of pervasive deformation and metamorphism (Plates 1 and 2). However, grading is observable in a few places where bedding is well defined, and is accentuated by cleavage refraction. The majority of psammite beds are fine to medium grained. They are commonly quartz-rich and the coarser grained beds contain angular bluish-grey quartz clasts. Psammite that is rich in calc-silicate minerals locally forms pods up to 15 cm across. These pods are massive, grey-weathering and speckled on fresh surfaces, and have concentric colour and compositional zoning.

The psammite beds are typically in sharp contact with pelite and semipelite beds. A strong, pervasive, tectonic foliation has destroyed most of the sedimentary structures in the pelite and semipelite, but because of their composition these rocks display the effects of metamorphism in the area better than the psammite. North of Gander Lake, the metamorphism is dominantly at chlorite grade, but south and east of the lake, higher grade rocks display two contrasting metamorphic effects. A regional aureole, characterized by

Plate 1. *Pelite and psammite of the Jonathan's Pond Formation (Unit 3), exposed on the north shore of Gander Lake. Thin beds of psammite have been transposed along the main flat-lying S2 foliation. The S1 foliation is preserved in pelite between the psammite bands.*

Plate 2. *Isoclinal, recumbent folds in pelite and psammite of the Jonathan's Pond Formation (Unit 3), north shore of Gander Lake.*

schists, is associated with the Hunts Ponds Granite (Unit 10), whereas hornfels forms a well-defined contact aureole around the Gander Lake Granite (Unit 11).

The effect of regional metamorphism on pelitic rock types is well seen in the southwestern part of the map area. Just west of the mouth of Fifteen Mile Brook, biotite pelite is fine grained and the foliation has a sericitic sheen, but as the grade increases, west of Rodney Pond, the rock becomes a coarse-grained biotite schist. Westward, dark-red garnet porphyroblasts, up to 5 mm across, become abundant in biotite–muscovite schists of the garnet zone. In the andalusite zone, andalusite crystals, up to 8 cm long, are common and appear to have randomly overgrown the foliation (Plate 3). Magnetite crystals, up to 3 mm across, are particularly abundant, in the biotite and garnet zones. At one locality, several kilometres southwest of Rodney Pond, numerous coticules of pink garnet and quartz form beds up to 3 cm thick. They are associated with abundant quartz veins that are locally rich in tourmaline.

Plate 3. *Andalusite porphyroblasts in mica schist of the Jonathan's Pond Formation (Unit 3). The schist is located in the regional metamorphic aureole associated with the Hunts Ponds Granite, south of Gander Lake and west of Rodney Pond.*

The contact metamorphic aureole around the Gander Lake Granite (Unit 11) is about 2 km wide and is best defined northeast of Gander Lake. The regional foliation is progressively obliterated with increasing grade. On fresh surfaces, the hornfels has a characteristic purplish hue that is caused by fine-grained, reddish-brown biotite. The hornfels retains its fine-grained nature from the lowest to the highest grade rocks, although low-grade rocks contain small indeterminate porphyroblasts and rocks in the cordierite zone are spotted with abundant, dark porphyroblasts of cordierite, up to 5 mm across.

Breccias consisting of diverse suites of psammitic, semipelitic and pelitic fragments in a finer grained matrix

occur at Home Pond and on the south shore of Gander Lake. The fragments are up to several centimetres across and are generally angular to subangular, although some are subrounded (Plate 4). The matrix to the larger fragments is composed of smaller fragments of the same material and a cement that appears to be recrystallized, suggesting that brecciation was premetamorphic.

Plate 4. *Subrounded fragments in a breccia zone in the Jonathan's Pond Formation (Unit 3), south shore of Gander Lake.*

Fine- to medium-grained, dark-green weathering, fine-grained mafic layers occur throughout the Jonathan's Pond Formation. They are especially common in the western part and form about 15 percent of exposures on the south shore of Gander Lake between the Gander Lake Granite and the Gander River Complex. The layers are mostly about 1 m thick, but range up to 20 m in thickness, and are generally concordant with the main foliation (S2).

A few felsic, intermediate, gabbroic and lamprophyric intrusions are also present within the Jonathan's Pond Formation. The most prominent felsic intrusion occurs on the north shore of Gander Lake, south-southwest of Deadmans Pond; it is several metres thick and contains quartz phenocrysts, up to 8 mm across, and feldspar phenocrysts, up to 1.5 cm across, in a dark aphanitic matrix.

Petrography: Unit 3

Chlorite Zone

Pelite and Semipelite: The typical assemblage is quartz, plagioclase, chlorite, muscovite, and accessory titanite, epidote, apatite and opaque minerals. Fine-grained muscovite and fine- to medium-grained chlorite are strongly aligned. Some quartz grains have pressure shadows, whereas others have been elongated, possibly by dissolution and recrystallization. Quartz also occurs in thin concordant veins and, in coarser grained rocks, with calcite and chlorite in post-foliation veins. Rounded titanite grains occur locally and appear to be detrital. Pyrite or magnetite porphyroblasts are abundant in some samples and are either synchronous with or postdate chlorite growth. West of the Gander Lake Granite aureole and south of Rodney Pond, magnetite porphyroblasts are common in the chlorite zone and many have symmetrical quartz-filled pressure shadows. Just west of Gambo, very fine-grained muscovite and chlorite pelites have a main foliation that is gently to moderately crenulated and overprinted by sericite and/or chlorite pseudomorphs after an unknown mineral.

The main foliation is S2, but evidence for an earlier foliation, S1, is preserved locally between S2 foliae (Plate 1). This early foliation is defined by very fine-grained muscovite and chlorite. Chlorite porphyroblasts grew after the formation of both S1 and S2, but predate an S3 crenulation cleavage.

Psammite: The mineral assemblage generally includes quartz, plagioclase, chlorite and muscovite, and accessory epidote, titanite, dark-bluish-green tourmaline, allanite and opaque minerals. Quartz, which is both mono- and polycrystalline, typically forms 70 percent of the rock and feldspar forms 10 percent; some grains display graphic intergrowths of quartz and feldspar. Some muscovite is coarse-grained and clearly detrital, whereas concentric zoning of some epidote grains suggests a metamorphic origin.

Lithic clasts include very fine-grained, cherty, polycrystalline quartz, very fine-grained sericite schist, fine-grained, strongly foliated, muscovite–quartz schist, and brown, sericite- and epidote-rich fragments that are probably of volcanic origin.

Quartzite beds occur in a few places and are composed of very well-rounded, subspherical to spherical quartz grains and minor amounts of calcite. Solution seams, up to 0.5 mm thick and spaced between 1.5 and 2 mm apart, contain chlorite, muscovite, epidote, titanite, tourmaline and probable allanite.

Chert layers exposed on Gander Lake have a banding defined by alternating finer and coarser grained quartz. The finer grained layers contain much more opaque material and are locally rich in albite; they also contain scattered coarse quartz grains. Quartz veins are abundant. A well-developed foliation is present in some fine-grained bands and is defined by elongate opaque minerals, quartz and chlorite. Some coarse-grained quartz veins are folded and have an axial-planar foliation.

Mylonitized quartz-rich rocks occur on the north shore of Gander Lake (UTM 673120E, 5424540N), southwest of

Gander hospital. The foliation is defined mostly by quartz platelets, opaque material, chlorite and abundant concordant quartz veins. Much of the quartz is recrystallized. The quartz veins are isoclinally folded around the axial planes that are parallel to the foliation.

The mineral assemblage in calc-silicate pods includes quartz, plagioclase, epidote, chlorite, apatite, titanite, opaque minerals and rarely actinolite. Some of the pods are associated with veins of quartz, epidote and chlorite.

Igneous Rocks: The mafic igneous rocks are completely recrystallized and show no primary igneous mineralogy or textures. The typical mineral assemblage is chlorite, quartz, plagioclase and ilmenite, and may include titanite, epidote, actinolite, biotite and calcite. Plagioclase grains are up to 4 mm across and in some samples are replaced by sericite, epidote and chlorite; albite locally forms 35 percent of the rock. The mafic rocks contain irregular clots of chlorite, quartz and a turbid brownish material; some of the chlorite in these clots has a plumose texture. Calcite is abundant locally. Actinolite is associated with green biotite in an exposure east of Cobbs Pond, and on the north shore of Gander Lake, just west of Gander, a banded mafic rock contains layers rich in fasciculate yellow-green actinolite, which alternate with epidote-rich layers.

Leucocratic gabbro is exposed at one locality on the north shore of Gander Lake. It contains coarse-grained plagioclase (60 to 65 percent), brown clinopyroxene (10 to 15 percent), chlorite (5 to 10 percent), opaque material including ilmenite (less than 5 percent), and minor biotite, titanite, serpentine, actinolite and muscovite. The serpentine occurs in scattered pseudomorphs, probably after olivine. Colourless to pale-green actinolite and muscovite also form pseudomorphs, replacing an unknown mineral, and sericite is locally abundant. A foliation is defined by chlorite and locally by elongate titanite grains.

Lamprophyre that occurs southwest of Deadmans Pond, on the Trans-Canada Highway (UTM 678000E 5421000N) contains albite (30 to 40 percent), brownish-red lamprobolite (25 percent), indeterminate opaque material (15 percent), and minor sericite and calcite.

Petrography: Unit 3 – Hunts Ponds Granite Aureole

Biotite Zone

Most of biotite-grade rocks associated with the Hunts Ponds Granite are on the south side of Gander Lake, but small areas at this grade, on the north side of the lake at Gander and between Gander and the Soulis Pond Metamorphic Zone, were probably metamorphosed during the same event.

Pelite and Semipelite: The mineral assemblage includes quartz, feldspar, biotite, muscovite, chlorite and sericite. Quartz and feldspar form a medium-grained, granoblastic mosaic with mainly curved grain boundaries, and the biotite is greenish brown.

The regional foliation (S2) is defined by biotite, muscovite, chlorite and locally by elongated quartz grains. The fabric-forming biotite is relatively fine grained and is overgrown by coarser static biotite porphyroblasts that contain straight inclusion trails of the the main foliation, and also by pseudomorphs of sericite replacing an unknown mineral. Locally, the main foliation is crenulated and biotite is aligned parallel to the axial planes of the crenulations, suggesting growth during D3; this S3 fabric is also defined by solution seams. Augen formed by the main fabric around some of the biotite porphyroblasts indicate further flattening of this fabric during D3.

In the one location southwest of Rodney Pond where coticules occur, garnet is the predominant phase in the manganese-rich beds. It is fine grained, up to 0.3 mm across and idiomorphic. Muscovite, biotite and quartz occur as accessory minerals.

Psammite: The typical mineral assemblage is quartz, plagioclase, greenish-brown biotite, muscovite, chlorite, sericite and minor amounts of epidote, allanite, tourmaline, apatite, titanite, zircon and opaque minerals. The rock is generally quartz-rich, but in a few places it contains as much as 45 percent feldspar.

Rounded quartz and feldspar grains preserve a relict clastic texture in a very fine-grained, polygonized matrix; some of the quartz contains rutile needles and some of the feldspar is perthitic. Muscovite and probably epidote also occur as detrital grains. Rock fragments include muscovite-bearing granite, probable volcanic clasts, which are rich in feldspar or epidote and titanite, metamorphic rocks containing muscovite and chlorite, and strongly foliated quartzite.

Igneous Rocks: Mafic rocks in the biotite zone have undergone complete recrystallization to chlorite-rich assemblages and most of the feldspars have been replaced by sericite and/or calcite. The rocks generally have a poorly developed foliation.

Garnet Zone

Pelite and Semipelite: At garnet grade and above, micaceous rocks are recrystallized to fine- to medium-grained schists. The typical garnet zone assemblage includes garnet, biotite, muscovite, chlorite and quartz.

The main foliation (S2) is generally defined by fine-grained muscovite and, where deformation was intense, quartz is also a fabric-forming mineral. Biotite has grown both parallel to the foliation and across it, and some biotite flakes are fish-shaped as a result of a later higher strain event. Garnet contains inclusion trails of the main fabric and these are locally curved. An earlier foliation (S1) is preserved in a few quartz-rich lithons and is overgrown by biotite.

Near the contact with the Gander River Complex, the main foliation is defined by fine-grained muscovite and

chlorite, and by elongate quartz grains, quartz plates and concordant quartz veins. In most cases, garnet and biotite–chlorite porphyroblasts overprint this foliation, but a few of the larger garnet porphyroblasts form augen within it and contain inclusion trails that are oriented obliquely. The fabric characterizes the high-strain zone associated with the contact between the Gander Group and the Gander River Complex (Goodwin and O'Neill, 1991) and is more intense than the main foliation (S2) in rocks farther east. It is possible that it is actually correlative with S3 in the latter rocks, but this can only be substantiated by more detailed work.

Igneous Rocks: Garnet zone rocks on the south side of Gander Lake (UTM 562100E 5420300N) are cut by a 1-m-thick, brown-weathering, dark-reddish-brown mafic intrusion. Intersertal plagioclase forms about 30 to 40 percent of the rock, and pyroxene occurs both as small colourless grains and as large, zoned, light-brown crystals that are locally fasciculate. There is also a small amount of brown hornblende, and calcite has formed pseudomorphs after both pyroxene and hornblende. The intrusion appears to have postdated the metamorphism.

Andalusite Zone

Pelite and Semipelite: The typical mineral assemblage is andalusite, biotite, muscovite, quartz and plagioclase, with or without garnet, staurolite, hornblende, chlorite or magnetite.

Strongly aligned biotite, muscovite and elongate opaque minerals define the main foliation (S2), and quartz forms a granoblastic matrix. An earlier foliation (S1) is preserved in microlithons and is defined by fine-grained muscovite, except locally where biotite is the fabric-forming mineral. Some fold hinges, to which the main foliation is axial planar, contain muscovite forming the S1 foliation and biotite forming S2.

Andalusite porphyroblasts contain abundant inclusions of quartz, biotite, garnet and muscovite and both the S1 and S2 fabrics occur as inclusion trails. The main foliation is also overprinted by biotite and garnet porphyroblasts. Some of the inclusion trails are oblique to the external foliation, implying relative rotation. Staurolite occurs in andalusite schist 3 km west of Gillinghams Pond and just west of Rodney Pond. It forms small (1 mm), sub-idiomorphic porphyroblasts and is overgrown by andalusite. Although the main foliation has been gently crenulated by a third event, this deformation has not been sufficient to form augen.

Chlorite occurs as vermicular inclusions in quartz and as a retrogression product of biotite. Sericite pseudomorphs probably represent retrogressed andalusite.

Calc-silicate Rocks: Psammitic pods rich in calc-silicate minerals are composed of quartz, feldspar, biotite, muscovite, garnet, hornblende and opaque minerals. Blue-green hornblende forms as much as 15 percent of these rocks and idiomorphic to sub-idiomorphic porphyroblasts of garnet are scattered throughout. Small amounts of biotite are present and feldspar is commonly sericitized.

Igneous Rocks: Mafic igneous rocks in the andalusite zone are represented by fine-grained concordant bands of amphibolite up to 2 m thick. Blue-green hornblende forms about 60 percent of the rock and sericitized plagioclase, quartz and chlorite about 20 percent; accessory minerals are epidote, titanite, apatite and opaque minerals. Hornblende defines the main foliation, but also forms augen within it, and posttectonic porphyroblasts and rosettes of hornblende have overgrown it.

Cordierite Zone

Pelite and Semipelite: Rocks of the cordierite zone are well exposed northwest of Gillinghams Pond, on the shore of Gander Lake, and southwest of Rodney Pond. The typical assemblage is cordierite, biotite, muscovite, quartz, garnet, andalusite, magnetite and chlorite. Staurolite is an additional phase in the schists east of Bluff Head, where it is enclosed in cordierite porphyroblasts.

Northwest of Gillinghams Pond, cordierite occurs as xenomorphic porphyroblasts, up to 1 cm across, in very coarse-grained muscovite–biotite schist. It encloses andalusite, biotite, muscovite, garnet, magnetite and radioactive grains and is partly or completely replaced by sericite. Garnet inclusions have straight, non-reactive boundaries, but biotite and andalusite are commonly rimmed by sericite and magnetite by chlorite.

The cordierite schist southwest of Rodney Pond is medium grained and contains andalusite and garnet porphyroblasts in a quartz–biotite–muscovite matrix. The main fabric (S2) is defined by muscovite and is crenulated. It forms inclusion trails in the cordierite and andalusite grains, but it is uncertain what the time relationship is between porphyroblast growth and crenulation.

Sillimanite Zone

Pelite and Semipelite: The highest metamorphic grade occurs near Bluff Head, on the shore of Gander Lake, and in a belt extending south toward Hunts Ponds. Coarse-grained schist contains fibrolitic sillimanite, as well as biotite, muscovite, quartz, plagioclase, garnet, tourmaline, opaque minerals and chlorite. Biotite and muscovite define the fabric in a granular quartz–plagioclase matrix. Fibrolite has commonly nucleated on biotite, which has subsequently been largely retrogressed to chlorite. Garnet grains are small and dispersed.

Petrography: Unit 3 – Gander Lake Granite Aureole

Exposures of the aureole rocks at the east end of Gander Lake contain the most complete set of index minerals. The aureole is also well exposed south of Rodney Pond, at the extreme southern edge of the map area.

Immediately west of Butts Pond (Map 93-15, back pocket), the aureole of the Gander Lake Granite overlaps northeast- and north-trending isograds associated with the Wing Pond Shear Zone. Isotopic dating shows that the Gander Lake Granite is younger than the shear zone, and relationships of metamorphic minerals in andalusite-bearing rocks support this conclusion. Isograds are therefore shown on the map as overlapping to be consistent with these observations. The granite-related biotite isograd is not shown south of Butts Pond because exposure and petrographic data are insufficient to distinguish it against a background of higher grade metamorphic assemblages related to the Wing Pond Shear Zone.

Biotite Zone

Pelite and Semipelite: The mineral assemblage consists principally of biotite, muscovite, plagioclase and quartz. In semipelitic rocks, medium- to fine-grained biotite and muscovite define the main regional fabric (S2) in a fine-grained unfoliated matrix of recrystallized quartz and plagioclase; grain boundaries in the matrix are straight or curved. Plagioclase is generally present in only minor amounts, but in the few places where it is abundant, it is altered to sericite and, locally, to epidote. Within pelitic bands, the main foliation is formed by pressure solution seams and crenulation of an earlier alignment of muscovite flakes.

Sericitized pseudomorphs are common and have possibly formed after cordierite or andalusite; they contain inclusion trails of biotite and quartz that are oblique or at right angles to the main fabric in the rock (S2), but in some cases bend into parallelism.

Cordierite Zone

Pelite and Semipelite: The typical assemblage includes cordierite, andalusite, biotite, muscovite, quartz, plagioclase and opaque minerals; garnet and tourmaline are common accessory minerals, and microcline and perthitic feldspar occur in the highest grade parts of the zone.

The main foliation (S2) is defined by very fine-grained biotite, chlorite or muscovite. Coarser grained biotite has overgrown the foliation or grown mimetically along it.

The porphyroblasts of andalusite are colourless to pink and commonly show at least some alteration to sericite. Even where this alteration has proceeded to completion, however, unaltered xenomorphic andalusite commonly accompanies the pseudomorphs. Andalusite typically contains numerous inclusions of biotite, muscovite, opaque minerals and locally garnet; the inclusions commonly define a relict foliation. In places, this included foliation occurs around the edges of the porphyroblasts and is continuous with the main foliation in the rock, but elsewhere the main foliation has been flattened around the porphyroblasts.

Cordierite porphyroblasts, up to 2 cm across, have overgrown all other phases in the aureole, including the andalusite porphyroblasts. In contrast to the other minerals, cordierite growth took place after the main fabric had been crenulated. Locally, the cordierite is almost completely altered to sericite and the pseudomorphs are rimmed by fine-grained biotite, which is partially retrogressed to chlorite.

Sillimanite Zone

Pelite and Semipelite: Sillimanite was found in only two places in the aureole of the Gander Lake Granite, in both cases within 500 m of the granite contact. One occurrence is just south of Rodney Pond, where small amounts of sillimanite occur in close association with cordierite in an andalusite–mica schist. At a second locality, on the south shore of Gander Lake, near the mouth of Joe's Brook, fibrolite occurs in a mica schist that also contains andalusite and staurolite. All of these minerals have been partially sericitized.

Unit 3 – Soulis Pond Metamorphic Zone

Distribution

The Soulis Pond Metamorphic Zone is a 1- to 3-km-wide belt of biotite-grade rocks that extends northeastward from Gander Lake to Soulis Pond within the area of ambient chlorite-grade metamorphism. The zone is parallel to a southeast-facing escarpment defining the general orientation of Soulis Pond and the brook that flows out of the pond at Benton. The zone is, however, oblique to the regional structural trend, and the main fabric in the Jonathan's Pond Formation (S2) swings from northerly outside the zone to northeasterly within it, as well as becoming steeper.

Petrography

Pelite and Semipelite: The typical assemblage in pelitic rocks is quartz, biotite, muscovite, chlorite, sericite and accessory epidote, titanite, apatite and plagioclase. Quartz, muscovite and chlorite form a very fine- to fine-grained, foliated matrix, which is overgrown by coarser grained biotite and muscovite in the more schistose rocks; there has been widespread retrogression of biotite to chlorite.

The main foliation (S2) is defined by fine-grained chlorite and muscovite and locally by biotite. This foliation has been overgrown by biotite porphyroblasts, up to 1.5 mm across, and by pseudomorphs after cordierite or andalusite; these consist of sericite, chlorite and biotite and are up to 2 mm across.

The main foliation has been heterogeneously crenulated by a third deformation, which is also responsible for small-scale mesoscopic folds (F3) and, where it is most strongly developed, forms a penetrative fabric (S3). The intensity of the S3 fabric is matched by increasing grain size in the micas and increasing frequency of pseudomorphs. Coarse-grained biotite is both crenulated by F3 and aligned parallel to S3, whereas coarse-grained chlorite has overgrown the crenulation and tends to be concentrated mimetically in bands parallel

to S3. The pseudomorphs overprint the F3 crenulation and contain inclusion trails of S2 that vary from straight to gently crenulated. Continuation of the third deformation is indicated by the wrapping of the S3 fabric around the pseudomorphs.

Psammite: The assemblage in psammitic rocks includes quartz, plagioclase, biotite, muscovite, chlorite, sericite, epidote, tourmaline, apatite, titanite and opaque material. Although these rocks are substantially recrystallized, some relict clasts are recognizable; they are elongated and internally polygonized. Thin concordant quartz veinlets are common.

Significance

Although the Soulis Pond Metamorphic Zone is contiguous with the aureole around the Gander Lake Granite, the two are thought to be unrelated because the rocks in the metamorphic zone are schistose, whereas those in the aureole are hornfels. It is possible that an intrusion similar to the Hunts Ponds Granite may occur at depth, but no granite has been observed at the surface. The most likely explanation for the anomalous metamorphism is uplift along an unexposed high-strain zone or brittle fault, which would also explain the topographic lineament and escarpment.

Unit 3 – Wing Pond Shear Zone

Definition and Distribution

The Wing Pond Shear Zone was first described by O'Neill and Lux (1989) and defined by O'Neill (1991b). Phyllonites, locally containing kyanite, sillimanite and andalusite, are best exposed at Wing Pond in the Weir's Pond area (NTS 2E/1) and strike southward to Gambo Pond in the Glovertown area (NTS 2D/9) (O'Brien *et al.*, 1991; O'Neill, 1992) for a minimum distance of 40 km. In the present map area (Map 93-15, back pocket), the phyllonites are exposed at Wing Pond, Gull Pond, Butts Pond and Square Pond (Plate 5). In most places, the width of the zone is about 3 km, but west of the town of Middle Brook the width increases to 6 km, although not all exposures have a high-strain fabric. The shear zone coincides with a regional, positive aeromagnetic anomaly along all of its defined length and it also lies close to the eastern boundary of the Indian Bay Big Pond Formation (Units 5 and 6).

The Wing Pond Shear Zone is not only characterized by a high-strain foliation, but it is also metamorphosed in the amphibolite facies and intruded by small bodies of gabbro and leucocratic muscovite, biotite–muscovite, and hornblende granite; all of these associated intrusions have heterogeneous high-strain foliations. Altered ultramafic rock of Unit 2 occurs near Butts and Square ponds, within the shear zone, and is assumed to have been tectonically emplaced.

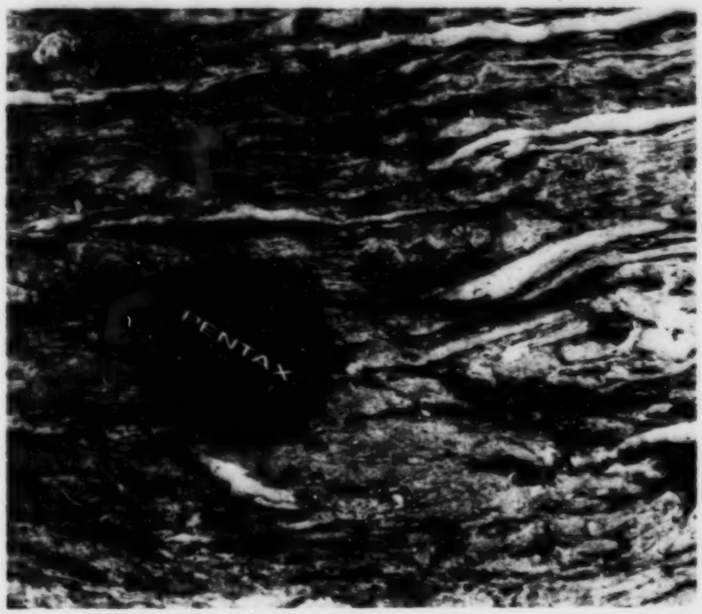


Plate 5. *Andalusite porphyroblasts forming augen in phyllonite of the Wing Pond Shear Zone, Jonathan's Pond Formation (Unit 3), near Square Pond.*

Mesoscopic Structure

Near Square Pond, the high-strain foliation strikes north to north-northeast and a steep northwesterly dip predominates. Tight, upright folds are developed in psammite and semipelite and their axial planes are subparallel to the high-strain foliation. They fold the regionally developed solution seam or pin-stripe banding (S2) in the Gander Group and are therefore designated F3 folds. The subparallel nature of the regional S3 and high-strain foliations in single exposures also suggests that the shear zone developed during the third deformation, and that the high-strain foliation is a more intense development of the S3 fabric. The asymmetry of the foliation and syntectonic folds suggest a dextral sense of shear.

Regional Relationships

West of Wing Pond, at the western edge of the Wing Pond Shear Zone, fine-grained pelitic and semipelitic rocks are metamorphosed at chlorite grade and contain both high- and low-strain foliations in single exposures. Less than 1.5 km to the east, on the western shore of the pond, a sharp increase in grade in uniformly high-strain rocks has produced sillimanite schists in the central part of the shear zone. A similar gradient is present between exposures west of Gull Pond and those on the south shore of the pond, where the rocks are coarse-grained sillimanite schists, locally containing profuse quartz and two-mica granite veins. On the railway line just south of Butts Pond, 1-m-thick granite dykes contain a strong fabric that is parallel to the high-strain foliation in adjacent psammites. The foliation in these rocks is axial planar to folds of the S2 pressure-solution cleavage, which is characteristic of large parts of the Jonathan's Pond Formation, and it is therefore interpreted to be S3.

A sharp metamorphic gradient is also present on the eastern side of the Wing Pond Shear Zone. At Middle Brook Provincial Park, 3 km east of Square Pond, dark-green biotite-grade chloritic phyllite has a high-strain foliation, within which an older fabric is preserved in microlithons and intrafolial folds. Numerous concordant quartz veins show pinch-and-swell structures and sense of shear indicators imply dextral motion. Two kilometres to the west, near Square Pond, the rock is a coarse-grained, high-strain schist, containing andalusite crystals up to 2 cm across. Along the Trans-Canada Highway, phyllonite encloses a pod of ultramafic rock (Unit 2).

Petrography

Separate areas within the Wing Pond Shear Zone are described individually because there is considerable variation in the development of high-strain fabrics and in the relationship of deformation to metamorphic mineral growth. The main consistant feature is the recrystallization of quartz subsequent to the principal shearing events.

Wing Pond Area: The high-strain fabric near Wing Pond is defined by muscovite, quartz platelets and concordant quartz veins, that are present in varying proportions depending on the original quartz content of the rock. The fabric is commonly accentuated by concordant seams of opaque material, 1 to 2 mm thick.

On the western shore of the Wing Pond, the phyllonite contains fine-grained sillimanite and fibrolite, which are locally crenulated and wrap around elliptical, coarse-grained pods formed of biotite, muscovite and sillimanite, or muscovite alone. Many of these pods contain central inclusions of relict andalusite or, in a few cases, coarse-grained sillimanite. The textural relationship between andalusite and sillimanite is not clear, but muscovite has replaced both minerals. Plagioclase is common and is associated with myrmekite.

Granitic dykes occur locally and contain a high-strain fabric, which wraps around porphyroclasts of quartz and plagioclase. The foliation is defined by medium- to coarse-grained, elongate and fish-shaped muscovite and biotite flakes, and by abundant concordant quartz veins.

Gull Pond Area: The feldspar in the quartzofeldspathic rocks from the south side of Gull Pond is mostly plagioclase. Quartz has undulose extinction, incipient sub-grain development, and granulated grain boundaries. Polygonal texture is locally present in both quartz and feldspar. The foliation is defined by fine- to medium-grained biotite and is overprinted by coarser grained muscovite and biotite. Many muscovite flakes are bent but not recrystallized.

At the southeast corner of Gull Pond, coarse-grained schists contain cordierite, sillimanite, garnet, biotite, muscovite, quartz and feldspar. Sillimanite is present both as needles and as brown felted masses of fibrolite; it has nucleated on biotite and appears to have replaced both biotite and coarse-grained muscovite. Corroded garnet occurs as inclusions in biotite, and cordierite contains abundant, resorbed biotite flakes, suggesting that biotite may have been one of the reactants during cordierite formation.

Coarse-grained rocks south of Gull Pond contain feldspar (up to 50 percent of the rock), quartz, muscovite, biotite, chlorite, sillimanite and opaque minerals. Feldspar shows a faint alignment and is extensively sericitized and hematized. Acicular chlorite and muscovite may be pseudomorphs after sillimanite, which is generally present in small amounts but in one sample occurs as elongate masses overprinted by coarse-grained muscovite. The high-strain fabric is heterogeneous and is defined by quartz, opaque minerals and very elongate muscovite (2 mm by 0.2 mm). Coarse-grained quartz in concordant veins has a ribbon texture and porphyroclasts of quartz and plagioclase form augen in the foliation.

Butts Pond Area: The schists on the railway line just south of Butts Pond contain biotite, muscovite, andalusite, sillimanite and kyanite. Sillimanite is concentrated in muscovite-rich seams along the grain boundaries of elongate muscovite flakes, with which it appears to be intergrown; it is the principal mineral defining the high-strain fabric. Microlithons of fine-grained muscovite preserve an older fabric, as does fine-grained biotite in adjacent biotite-rich layers that are also characterized by coarse, fish-shaped biotite flakes. Andalusite porphyroblasts form augen in the high-strain foliation and overprint the older fabric, which occurs as crenulated inclusion trails of muscovite; the andalusite contains abundant inclusions of kyanite. In the exposure closest to Butts Pond, the main high-strain foliation has been crenulated, and elongate muscovite has grown parallel to the axial planes of the crenulations.

Coarse-grained schist north of Butts Pond contains sillimanite, cordierite, muscovite, biotite, chlorite, quartz, plagioclase and minor amounts of perthite and myrmekite; magnetite is locally abundant. The quartz and feldspar matrix is medium-grained and grain boundaries are typically straight, although in places quartz is lenticular or ribboned. Fibrolite defines an anastomosing fabric, which is overprinted by muscovite porphyroblasts; the latter have been kinked by subsequent deformation. Porphyroblasts of cordierite overprint both muscovite and sillimanite and chlorite has formed by retrogression of biotite.

On the railway line, where the Wing Pond Shear Zone overlaps the aureole of the Gander Lake Granite, andalusite-bearing schist of the shear zone is strongly retrogressed. The rock is slightly coarser grained than most of the aureole rocks, but the shear-zone foliation is poorly preserved. Andalusite porphyroblasts are rimmed by sericite and much of the biotite is altered to chlorite.

Middle Brook Area: The foliation west of Middle Brook is defined by fine-grained muscovite and biotite, and has been crenulated by subsequent deformation. Quartz is mostly recrystallized to a polygonal mosaic, but some elongated quartz grains are preserved and illustrate the high-strain

nature of the foliation. Coarse-grained biotite appears to postdate the main foliation, as does idiomorphic to subidiomorphic garnet. Disturbance of the main foliation around the garnet grains may have been caused by the crenulation event. The garnet is commonly rimmed by chlorite and/or biotite, and biotite is partially retrogressed to chlorite.

Square Pond Area: The foliation east of Square Pond is defined by quartz, muscovite and concordant quartz veinlets, some of which are isoclinally folded. Aggregates of kyanite crystals occur in coarse-grained schists and are enveloped by fabric-forming muscovite. Coarse-grained biotite is also associated with the kyanite, and locally, andalusite encloses both the biotite and kyanite. The andalusite is commonly retrogressed to sericite, and plagioclase has been hematized and slightly sericitized. Occurrences of strongly foliated and lineated calc-silicate rock have a foliation that is defined by green hornblende and biotite and is overgrown by idiomorphic garnet.

North and east of Square Pond, phyllonite has a medium- to high-strain foliation, defined by muscovite and quartz (Plate 5). The quartz is variably recrystallized, but still preserves much of its ribbon texture, and locally small areas of granoblastic polygonal quartz are surrounded by ribbon quartz. Fibrolitic sillimanite occurs on the east side of Square Pond and is aligned parallel to the foliation. In some places, it coexists with andalusite and is overgrown by coarse-grained muscovite.

Along the Trans-Canada Highway, north of Square Pond, phyllonite contains quartz, plagioclase, muscovite, biotite, andalusite and sillimanite, and concordant quartz veins. Quartz and plagioclase contain inclusion trails of opaque material, and myrmekite is developed at quartz–plagioclase grain boundaries. Some quartz grains are elongate and ribbon quartz is interleaved with mica films defining the foliation, which is asymmetric and wraps around coarse-grained, fish-shaped muscovite flakes. Fibrolite is locally developed in masses parallel to the foliation, and is the main fabric-forming mineral in the phyllonite adjacent to the outcrop of ultramafic rock (Unit 2) on the Trans-Canada Highway. Andalusite relics, containing kyanite inclusions, occur in low-strain augen, but andalusite also overprints the foliation and in some cases has grown along it.

First Burnt Pond Area: South of First Burnt Pond, phyllonite contains numerous quartz veins, which preserve a ribbon texture. Muscovite is aligned along the foliation, but is recrystallized to form a fine- to medium-grained mosaic with abundant late chlorite. Sericitized pseudomorphs overprint this mosaic.

Significance

Substantial dip-slip movement is implied for the Wing Pond Shear Zone by the juxtaposition of the medium-pressure and medium- to high-temperature rocks, within the shear zone, with the chlorite-grade metasedimentary rocks on either side of it. Strike-slip movement, principally with a dextral sense of shear, is indicated by kinematic indicators. The relative timing of different shear components is unknown.

At least locally (near Indian Bay Big Pond, NTS 2E/1, and Wing Pond), the high-strain zone coincides with the southeastern margin of the Indian Bay Big Pond Formation. Because of the degree of deformation and the dip-slip movement, it is not everywhere clear whether rocks in the shear zone belong to the Jonathan's Pond or the Indian Bay Big Pond Formation, or if they even belong to the Gander Group at all. It is possible that some are derived from a unit that underlies the Gander Group. The presence of the shear zone implies that the Gander Group is not a continuous sequence and that the southeastern belt of the group (east of the shear zone) may be a structural repetition of the northwestern belt.

The spatial association of the Wing Pond Shear Zone with a positive aeromagnetic anomaly may be explained by inferring a mafic–ultramafic complex in the subsurface, a hypothesis that is supported by the two ultramafic occurrences. The emplacement of such a complex might have caused the high-metamorphic temperatures in the shear zone, and also may have been responsible for partial melting to produce the granitic bodies. Alternatively, the anomaly may reflect the relative elevation of basement rocks of this composition by dip-slip movement. Another contributing factor to the aeromagnetic anomaly is likely to have been magnetite-producing reactions resulting from the higher grade of metamorphism.

Lithology: Unit 4

Unit 4 is distinguished from Unit 3 by the presence of black to dark-grey, graphitic pelite layers that are interbedded with the dark-grey psammite and white-weathering quartzite beds that are typical of the Jonathan's Pond Formation. Both psammite and quartzite beds range up to 2 m in thickness, and the psammites are characterized by a close-spaced solution seam cleavage. The most micaceous beds contain dark-green porphyroblasts of chlorite set in a very fine-grained matrix.

Petrography: Unit 4

The pelitic and semipelitic beds are very fine-grained and contain sericite, chlorite, quartz, graphite and other opaque minerals, overgrown by porphyroblasts of chlorite. A moderate to strong foliation is defined by solution seams rich in sericite, chlorite and opaque minerals, and by elongated quartz.

The psammite consists of quartz (up to 80 percent of the rock), plagioclase (up to 10 percent), local concentrations of albite, turbid feldspar, chlorite, muscovite, titanite, epidote, opaque minerals, tourmaline, zircon and calcite. Quartz has a bimodal grain-size distribution, which is probably an effect of metamorphic recrystallization of detrital grains. Detrital

muscovite flakes are dispersed throughout the rock and fine-grained, metamorphic chlorite is abundant. Rounded epidote grains and some titanite grains may be detrital, but euhedral titanite that is clearly not detrital is present in veins.

Indian Bay Big Pond Formation (Units 5 and 6)

Distribution, Contact Relationships and Age

Rocks assigned to the Indian Bay Big Pond Formation occur just west of Wing Pond and northeast of the eastern end of Gander Lake (Map 93-15, back pocket). Each area contains its own distinctive rock types, but rocks in both places resemble parts of the Indian Bay Big Pond Formation as defined in the Weir's Pond area (NTS 2E/1) (O'Neill, 1991b) and both localities are along strike from the type area.

Contact relationships with the Jonathan's Pond Formation are unknown because of poor exposure within the map area. The dominant clast type in conglomeratic parts of the formation is psammite, similar to the ubiquitous psammite beds of the Jonathan's Pond Formation. Such a provenance would imply an unconformity between the Jonathan's Pond and Indian Bay Big Pond formations. However, relationships in the Weir's Pond area suggest that stratigraphic continuity is more likely (O'Neill, 1991b). In this case, the psammite clasts would have been derived from older rocks, which may also have been a source of the quartz-rich sediments of the Jonathan's Pond Formation.

The age of the Indian Bay Big Pond Formation in the map area is assumed to be late Arenig to early Llanvirn, based on the correlation with the type locality of the formation in the Weir's Pond area, which contains dated brachiopods and trilobites (Wonderley and Neuman, 1984; Boyce *et al.*, 1988; O'Neill, 1991b).

Lithology: Unit 5

At Wing Pond, exposures of the Indian Bay Big Pond Formation consist principally of grey to purple conglomerate, interbedded with grey sandstone (subunit 5a), but there is also an exposure of maroon siltstone (subunit 5b) near the southwest end of the pond.

The conglomerate (Plate 6), in more westerly exposures, consists of pebbly beds that are mainly grey- or white-weathering. It is interbedded with quartzose sandstone that is lithologically similar to psammites of the Jonathan's Pond Formation. Farther east, cobble-rich beds predominate and these weather purple or mottled purple and white. They are similar to the conglomerate boulders that are abundant on the shores of Indian Bay Big Pond in the Weir's Pond area (NTS 2E/1) (O'Neill, 1991b).

The conglomerate clasts are well rounded and up to 20 cm across. Most consist of fine- to medium-grained psammite and, in the cobble conglomerate, the matrix appears to consist of the same material as the clasts. Some of the cobbles have thin (less than 5 mm) weathered rims; it is not known if this is a pre-incorporation feature, implying a subaerial depositional environment, or a recent affect.

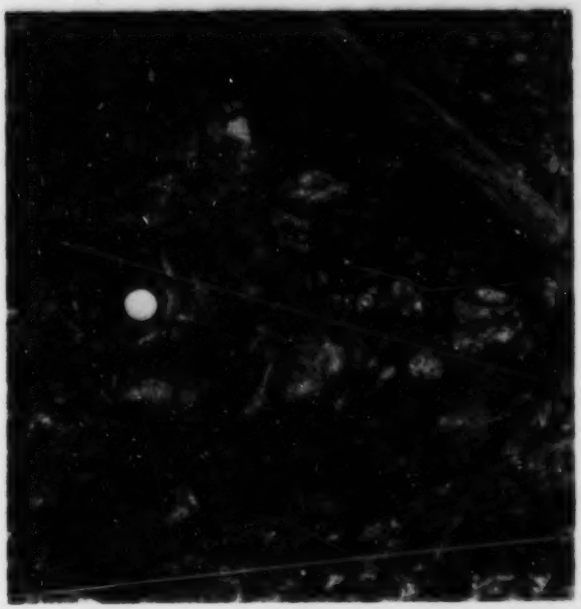


Plate 6. *Conglomerate of the Indian Bay Big Pond Formation (subunit 5a), west of Wing Pond.*

Lithology: Unit 6

The exposures of the Indian Bay Big Pond Formation near the east end of Gander Lake consist of interbedded black pelite and thin- to medium-bedded, greyish white to dark-grey psammite. The black pelite beds also contain grey to white psammite laminations and thin calc-silicate beds. Both pelite and psammite beds are cut by profuse networks of quartz veins.

Petrography: Unit 6

The psammite is medium-grained and contains rock fragments that include foliated quartz and white mica aggregates, shale (now recrystallized to schist), crenulated graphitic black shale and a fine-grained, polycrystalline, quartz-rich rock. Monomineralic grains consist of quartz, plagioclase, muscovite or tourmaline. Many of the quartz grains are angular and plagioclase is slightly sericitized.

The black pelite in chlorite-grade rocks consists of a matrix of muscovite and chlorite that is overgrown by garnet porphyroblasts up to 0.3 mm across; the garnet is presumed to be spessartine. In the biotite and higher grade rocks of the Gander Lake Granite aureole, biotite is present as a fabric-forming mineral in the matrix and the foliation is crenulated; the crenulations have been overgrown by porphyroblasts that are now completely retrogressed.

Calc-silicate beds within the pelite contain quartz, very fine-grained epidote, pale-green actinolite and titanite. They are crosscut by veins of coarse-grained quartz, epidote, actinolite and titanite.

DAVIDSVILLE GROUP

Weir's Pond Formation (Unit 7)

Distribution, Contact Relationships and Age

The Weir's Pond Formation of the Davidsville Group occurs along the western edge of the map area. It is complexly imbricated with the ophiolitic rocks of the Gander River Complex and is in inferred tectonic contact with the Jonathan's Pond Formation. The best exposures are on the southern shore of Gander Lake and, except where otherwise stated, the descriptions given below apply to the rocks in this area. These units formed the 'Mixed Member' of McGonigal (1973), which he included in the Gander Group. Blackwood (1980) placed these rocks in the Davidsville Group and they were assigned to the Weir's Pond Formation by O'Neill and Blackwood (1989).

Fossil localities in the Weir's Pond Formation contain faunas of three distinct ages. Late Arenig to early Llanvirn brachiopods and trilobites occur in argillaceous sandstones on the shore of Gander Lake and in the country to the north (McKerrow and Cocks, 1977; Boyce *et al.*, 1988). At Weir's Pond, limestone contains a varied fauna that includes brachiopods, trilobites and conodonts of late Llanvirn–early Llandeilo age (Neuman in Blackwood, 1978; Stouge, 1980; Boyce *et al.*, 1988). Shales and slates overlying the limestones contain Caradoc graptolites (Erdtmann in Williams, 1972; Dean, 1978a).

Lithology

North of Gander Lake, the Weir's Pond Formation comprises black to greyish-green shale, fine- to coarse-grained sandstone, and conglomerate. On the southern shore of Gander Lake (the only exposures of Weir's Pond Formation mapped in detail for this study), the formation consists of interbedded black shale (locally graphitic), siltstone, dark-grey, fine- to medium-grained sandstone, greenish-grey, coarse-grained sandstone, and conglomerate. South of the lakeshore, the few exposures consist of black shale.

Several hundred metres east of the mouth of Richards Brook, black shales and associated coarser grained sedimentary rocks have a very strong foliation, mostly defined by elongation of feldspar and quartz grains. The black shale locally contains 1-cm-thick hornblende-, biotite- and quartz-rich bands. Interbedded thin, silty or sandy black layers, termed here 'pebbly siltstone', contain dispersed feldspar and bluish-grey quartz grains, up to 5 mm across. Grey-green, fine- to medium-grained sandstone beds, containing biotite and muscovite, are interbedded with the 'pebbly siltstone'.

The sandstones are generally fine to medium grained and weather grey or rarely brownish grey. Distinctive white-weathering, strongly foliated, granular sandstone, having greenish specks and light green layers, is exposed over an outcrop width of 15 to 20 m. The sandstones contrast with those of the Jonathan's Pond Formation (Units 3 and 4) in that they are relatively quartz-poor and do not alternate regularly with pelitic and semipelitic beds. Fine-grained calcareous layers and lenses are interbedded with greenish-grey sandstone in one locality. They are generally less than 10 cm thick and weather recessively.

Near the mouth of Richards Brook, 5 to 10 m of distinctive, pebbly conglomerate is interbedded with several tens of metres of black shaly siltstone. The conglomerate contains numerous black shale fragments, quartz-feldspar aggregates and milky quartz grains, and some clasts appear to be of volcanic origin. The clasts have been intensely flattened parallel to the cleavage.

Thin-bedded mafic layers rich in calc-silicate minerals are locally abundant and may form up to 50 percent of individual exposures. Many of them appear to be interbedded with other rock types and so may represent mafic tuffs, rather than flows or intrusions.

Petrography

On the south shore of Gander Lake, most of the Weir's Pond Formation lies within the biotite zone, whereas the part to the north of the lake is in the chlorite zone. The following description refers to exposures on the southern shore only.

The typical mineral assemblage in the shales is biotite, chlorite, muscovite, quartz and carbonaceous material. The main penetrative foliation, which is heterogeneous and locally crenulated, is defined by muscovite, chlorite and carbonaceous material and is postdated by a solution-seam cleavage. The penetrative foliation is overprinted by reddish-brown biotite porphyroblasts, up to 0.8 mm across. Some of the porphyroblasts contain inclusion trails and some of these define microfolds. Biotite grains abut sharply against the solution seams and do not overgrow them. However, the main foliation locally wraps around the biotite porphyroblasts, indicating some deformation after growth.

The hornblende-rich layers in the shale contain fasciculate bundles and rosettes of hornblende, dusty and sericitized feldspar, and titanite. The fabric defined by opaque minerals is overprinted by the hornblende.

The black 'pebbly siltstone' contains dusty sericitized feldspar clasts and porphyritic quartz-plagioclase rock fragments, as well as a few thin biotite-rich bands and lenticles of very fine-grained quartz. The siltstone has a strongly heterogeneous foliation, which is generally defined by graphite and chlorite seams but is also formed by narrow films of biotite in finer grained varieties of the rock. In these cases, the biotite itself does not display any high strain effects and

may have grown mimetically on a pre-existing fabric. Other fabric-forming elements are concordant quartz veins and flattened quartz and feldspar aggregates. Matrix quartz is completely recrystallized and rosettes of hornblende overprint both biotite and quartz.

Southwest of Gillinghams Pond, the black shale in contact with altered ultramafic rock has a strong crenulation cleavage defined by fine-grained carbonaceous material concentrated along the crenulation seams. Biotite porphyroblasts are abundant and are concentrated between the carbonaceous seams. Some biotite grains end abruptly at the seam boundaries, but others clearly overprint the crenulations. Andalusite porphyroblasts have overgrown biotite and also postdate the crenulation. This is the only observed occurrence of porphyroblast growth after the development of the late cleavage in the Weir's Pond Formation.

The grey-weathering sandstone contains a moderate foliation, which is defined by chlorite, calcite, an elongate opaque mineral and ellipsoidal, recrystallized quartz aggregates. Some concordant quartz platelets are present and the quartz fibres have aspect ratios of 10 to 1. In one sample, very fine-grained biotite forms the foliation and is overprinted by slightly coarser biotite. Calcareous layers contain quartz (up to 15 percent), graphitic seams, and minor muscovite and chlorite, as well as calcite.

The white-weathering, granular sandstone contains 60 to 70 percent quartz, 15 to 20 percent feldspar and up to 15 percent calcite; chlorite and sericite occur in trace amounts. The quartz is completely recrystallized and feldspar grains are hematized, particularly in their cores. Some clasts contain graphic intergrowths of quartz and sericitized feldspar and others are cherty. The sandstone locally contains graphitic seams, which are parallel to the foliation defined by elongated quartz and feldspar grains and concordant quartz veins.

North of Gander Lake, pebbly sandstone exposed on the Trans-Canada Highway contains abundant single grains of quartz and plagioclase (including chessboard albite); the plagioclase is extensively sericitized. Euhedral to anhedral garnet, up to 1 mm across, and chromite and magnetite are abundant. Biotite is common but much of it is retrogressed to chlorite. White mica occurs in minor amounts. 'Schistose' fragments, 0.2 by 0.5 mm, contain elongate opaque minerals in a chlorite–muscovite matrix; in many fragments, the matrix is foliated and in some the foliation is crenulated or oblique to that in the enclosing rock. Porphyritic volcanic or sub-volcanic fragments contain biotite and garnet and there are also abundant clasts of fine-grained felsic volcanic rock. Clinozoisite is common and is fresh where it replaces feldspar, but is turbid in the matrix; most of it has probably been produced by low-grade metamorphism.

The typical mineral assemblage in the mafic rocks is actinolite or hornblende (up to 60 percent), chlorite, white mica (up to 20 percent), quartz and opaque material. The actinolite is colourless to pale green and the hornblende pale-brownish-green. Most of the amphibole is aligned parallel to the foliation, defined primarily by fine-grained pyrite, but coarse-grained amphibole rosettes are younger and have overgrown the foliation.

Amphibole-rich rock that is locally interlayered with greyish-green shale has a foliation defined by fine-grained actinolite, chlorite and carbonaceous seams. These phases are overprinted by porphyroblastic rosettes of pale-green actinolite. Some layers that contain abundant carbonaceous material also contain muscovite, quartz, biotite and pale-greenish-brown amphibole.

PLUTONIC INTRUSIVE ROCKS

Gabbro in Wing Pond Shear Zone (Unit 8)

Distribution, Contact Relationships and Age

Small gabbroic bodies are exposed at several places in the Wing Pond Shear Zone, particularly on the west side of Wing Pond, southwest of Gull Pond and adjacent to Square Pond. The gabbro is everywhere associated with granite (Plate 7). The contacts between the gabbro and metasedimentary rocks of the Gander Group are generally sharp, whereas contacts between the gabbro and crosscutting granitic sheets and included granitic blocks are gradational over several millimetres.

Plate 7. *Medium- to coarse-grained gabbro (Unit 8) intruded by foliated granitic sheets (Unit 9) in the Wing Pond Shear Zone on the west side of Wing Pond.*

The precise age of the gabbro intrusions is not known, but it is most likely to be Silurian because $^{40}Ar/^{39}Ar$ dating (see section on Geochronology) indicates a Silurian age for metamorphism in the Wing Pond Shear Zone, which is probably related to the gabbro and granite intrusions.

Lithology

The gabbro typically consists of medium- to coarse-grained hornblende and plagioclase. The effects of deformation are heterogeneous; much of the gabbro appears to be massive but locally there is a moderate to well-developed foliation. Granitic sheets cut the gabbro, which also locally contains angular granitic blocks, up to 15 cm across. The gabbro is unfoliated where it contains granite blocks.

Petrography

Gabbro exposed on the west side of Wing Pond contains approximately equal proportions of hornblende and plagioclase, with accessory quartz, titanite, ilmenite and chlorite. Most of the hornblende has dark-green to light-brown pleochroism, but secondary pale-green hornblende is also present in minor amounts. The plagioclase is almost completely sericitized.

On the southwest shore of Gull Pond, gabbro contains numerous granitic blocks. It consists of hornblende (70 to 80 percent), plagioclase (15 percent) and accessory epidote, titanite and quartz. The hornblende is pale green to deep green, and much of it occurs as fine- to medium-grained recrystallized aggregates; the plagioclase is mostly sericitized. Amphibolite occurs south of the pond, where it contains bluish-green and minor brownish-green hornblende (60 percent), quartz and plagioclase (25 percent) and minor titanite and biotite.

Bluish-green and very pale-green actinolitic hornblende is common in gabbro exposed on the north shore of Square Pond. Minor amounts of epidote and clinozoisite occur as alteration products of plagioclase. Locally, a sub-assemblage of brown biotite, epidote, clinozoisite and fine-grained muscovite occurs at the grain boundaries between plagioclase and probable ilmenite, which is rimmed by titanite.

Granite in Wing Pond Shear Zone (Unit 9)

Distribution, Contact Relationships and Age

Granite occurs throughout the Wing Pond Shear Zone and is locally associated with gabbro of Unit 8. It is subdivided on the basis of its content of ferromagnesian minerals and muscovite.

Muscovite granite (subunit 9a) is exposed on a small island in the southwest corner of Gull Pond, and garnetiferous muscovite granite occurs on the northeast shore of Square Pond and as veins, less than 2 m thick, cutting gabbro near Gull Pond. At both Wing and Gull ponds, muscovite granite is minor compared to gabbro and occurs mostly as veins or xenoliths in the gabbro bodies. The granite cuts strongly foliated schists along the Trans-Canada Highway, north of Square Pond, and is itself foliated. Immediately southwest of Gull Pond, it intrudes medium- to coarse-grained gabbro, which in turn cuts coarse-grained muscovite schist and psammite; similarly, on one of the islands in the pond, granite dykes with a steep, strong foliation cut gabbro and contain numerous xenoliths of schist and psammite.

Biotite granite (subunit 9b) is exposed on a small island in the southwest part of Gull Pond and one exposure occurs on the north shore of Square Pond. A concordant biotite granite vein, less than a metre thick and containing disseminated pyrite, is interlayered with the metasedimentary rocks (Unit 3), adjacent to the ultramafic rock (Unit 2) on the abandoned railway line.

Two exposures of muscovite–biotite granite (subunit 9c) occur near the southeast corner of Butts Pond. Hornblende granite (subunit 9d) is exposed on both the north and south sides of Square Pond, and on the southwest shore of Gull Pond.

Granites of Unit 9 appear to be approximately the same age as gabbro of Unit 8 and are assumed to be Silurian on the same indirect evidence.

Lithology and Petrography

Muscovite Granite (with or without garnet) (subunit 9a)

The muscovite granite is typically equigranular and fine to medium grained. It is commonly foliated and locally has a high-strain fabric. Mylonitic granite forms dykes south of Gull Pond, on the northeast side of Square Pond and along the Trans-Canada Highway. Porphyroclasts of quartz, microcline and plagioclase are enveloped in a very fine-grained, foliated matrix of quartz and feldspar, and concordant quartz veins are abundant; muscovite forms seams parallel to the fabric.

The muscovite granite contains about equal amounts of quartz and feldspar. Quartz is typically polygonized in the rocks that have been deformed and grain boundaries vary from straight to lobate. Plagioclase is zoned and is commonly sericitized and hematized, particularly in grain centres. Muscovite forms up to 10 percent of the granite and is locally aligned along the fabric. Accessory minerals include biotite, which is variably retrogressed to chlorite, and apatite, epidote, and titanite. Garnet and tourmaline are prominent minor constituents in some of the dykes.

Biotite Granite (subunit 9b)

The biotite granite is equigranular, medium-grained and weakly foliated. It consists of quartz, plagioclase, microcline, biotite and accessory minerals. Inclusions of biotite schist and psammite locally form up to 30 percent of the rock.

The outcrop of the granite on the north shore of Square Pond has a visually estimated modal composition of 30 percent quartz, 25 percent plagioclase, 20 percent microcline, 10 to 15 percent biotite, 5 percent euhedral titanite, and accessory muscovite, epidote, chlorite, sericite and opaque

minerals. Microcline forms the largest grains, up to 1 cm across, and some of the plagioclase is concentrically zoned. A mortar texture is locally developed, consisting of a fine-grained matrix of biotite and quartz enveloping large grains of microcline, many of which are fractured. A moderate to poor foliation is defined by aligned biotite and inequant quartz and feldspar.

The biotite granite dyke in metasedimentary rocks of Unit 3 on the abandoned railway is similar to the granite at Square Pond. However, most of the feldspar is sericitized and contains apatite needles, and many of the quartz grains have needles of rutile. Pyrite is an accessory phase.

Biotite granitoid occurs as xenoliths in gabbro on the southwest side of Gull Pond. Quartz is polygonized and grain boundaries are curved to straight. Plagioclase, which is the only feldspar, is zoned and contains biotite and chlorite inclusions; it is extensively sericitized and hematized. Accessory prehnite occurs in veinlets, in feldspar grains and is also disseminated throughout the rock. The rock has been invaded by narrow veins of very fine-grained mafic material that wrap around individual grains.

Also on the southwest side of Gull Pond, cataclastically foliated biotite granite is exposed on a small island. Much of the biotite is retrogressed to chlorite and the foliation is defined by chlorite, and very fine-grained opaque material, muscovite and epidote or titanite. The foliation locally wraps around porphyroclasts of quartz and feldspar, but most quartz between the anastomosing foliae is polygonized; in places CS fabrics are developed.

Muscovite–Biotite Granite (subunit 9c)

The muscovite–biotite granite is white-weathering, fine- to medium-grained, equigranular and has a moderately developed foliation.

Hornblende Granite (subunit 9d)

Hornblende granite on the southern shore of Gull Pond is strongly foliated. It contains about 25 percent hornblende, which has dark-green to yellowish-green pleochroism. Plagioclase, which is partly sericitized, forms about 50 percent of the rock and quartz forms about 20 percent. Large euhedral to subhedral titanite crystals are prominent.

On the north shore of Square Pond, the granite is unfoliated. The rock is fine to medium grained and contains plagioclase (35 percent), quartz (20 percent), hornblende (25 percent), chlorite (less than 10 percent), and accessory titanite, apatite, sericite, ilmenite and epidote. The hornblende is mostly deep green, but bluish green locally, and the plagioclase is extensively sericitized. Titanite grains are up to 1 mm across and form rims on some of the opaque grains, which are probably ilmenite.

The hornblende granite exposed on the south side of Square Pond is composed mainly of sericitized feldspar (60 to 70 percent) and quartz (20 percent); all identifiable feldspar is plagioclase. Accessory minerals are pale-green to bluish-green hornblende, chlorite, titanite and epidote. A strong foliation is defined by ribboned quartz, inequant feldspars and seams of chlorite and opaque material.

Hunts Ponds Granite (Unit 10)

Definition, Contact Relationships and Age

The name, 'Hunts Ponds Granite', is formally proposed for the equigranular, garnet–biotite–muscovite granite that outcrops in the area of Gillinghams and Hunts ponds (Blackwood, 1982), and also occurs in numerous small exposures near the west end of Rodney Pond. In the same area, the Gander Group contains concordant or crosscutting sheets of a similar leucocratic granite, many of which are pegmatitic. Contacts between the granite and the Gander Group vary from sharply intrusive, where the metamorphic grade is low, to more gradational at higher grades.

The precise age of the granite is unknown, but based on $^{40}Ar/^{39}Ar$ determinations on samples of the enclosing Gander Group (O'Neill and Lux, 1989; *this report*), it is most likely to be Late Silurian or Early Devonian. Contemporary metamorphism and granite intrusion is indicated, for example, by a small granite vein on the south shore of Gander Lake, which is related to the Hunts Ponds Granite and has intruded andalusite schist of the Gander Group. A foliation in the vein parallels the axial-planar foliation related to crenulation of the main (S2) fabric in the metasedimentary rocks. Thus the timing of granite intrusion, between the second and third deformations, corresponds to porphyroblastic mineral growth in the country rocks. O'Neill and Lux (1989) suggest that $^{40}Ar/^{39}Ar$ cooling ages in the Weir's Pond area (NTS 2E/1) correspond to the D3 event itself, so that their Early Devonian range of about 400 to 385 Ma would slightly postdate granite intrusion.

Lithology and Petrography

The granite is composed of quartz (30 percent), plagioclase (50 percent), microcline (10 to 20 percent), muscovite (up to 15 percent), and minor amounts of biotite, garnet and chlorite. The rock is generally equigranular and medium grained. Plagioclase crystals have discontinuous, displaced twins and microcline locally contains abundant rounded inclusions of quartz; both feldspars have been hematized. Biotite is partially retrogressed to chlorite. Garnet is idiomorphic and encloses quartz and feldspar.

Locally, the granite is banded on a centimetre scale and the bands are defined by alternating quartzofeldspathic and mica-rich layers; some of the latter contain concentrations of garnet. Metasedimentary xenoliths are common in a few localities. Pegmatite is characteristically associated with the granite and commonly contains muscovite, garnet, tourmaline and disseminated pyrite. Much of the intrusion appears to have been cataclastically deformed and then recrystallized.

Gander Lake Granite (Unit 11)

Definition, Contact Relationships and Age

The name, Gander Lake Granite, is formally proposed for the granite that underlies much of the central part of the map area and is best exposed on the southern shore of Gander Lake. The granite was first mapped by Jenness (1963) and was referred to informally by Strong *et al.* (1974) as the Gander Lake pluton. It extends southward into the Dead Wolf Pond (NTS 2D/10) and Glovertown (NTS 2D/9) areas (Blackwood *et al.*, 1991; O'Brien *et al.*, 1991).

At the margin of the intrusion, granite sheets that are tens of metres thick alternate with hornfels derived from the Gander Group and extend hundreds of metres into the country rocks. Narrow, tourmaline-bearing pegmatites also commonly cut the metasedimentary rocks. The contact between the main body of the granite and the Gander Group on the south side of Gander Lake is marked by a zone, a metre or less across, in which granitic veins have intruded along the foliation and bedding of the metasedimentary rocks (Plate 8). In contrast, the granite adjacent to the contact on the Trans-Canada Highway is extensively shattered and the country rocks are highly sheared, suggesting the presence of a fault.

Plate 8. *The contact between the Gander Lake Granite (Unit 11) and metasedimentary rocks of the Jonathan's Pond Formation (Unit 3), south shore of Gander Lake.*

The only radiometric age for the Gander Lake Granite was determined using the K–Ar method and gave a result of 357 ± 25 Ma (Lowdon, 1960). This age is compatible with field relationships, which indicate that intrusion postdated Siluro-Devonian regional metamorphism in the Gander Group (O'Neill and Lux, 1989; *this report*). The Gander Lake Granite also bears a general resemblance to the Ackley Granite Suite in southern Newfoundland, which has yielded age determinations ranging from Middle Devonian to Early Carboniferous (Dallmeyer *et al.*, 1983; Kontak *et al.*, 1988; Mandville, 1991).

Lithology

The Gander Lake Granite is a pink, massive, homogeneous, medium- to coarse-grained, porphyritic granite. Potassium feldspar phenocrysts, which range up to 6 cm in length, are surrounded by a quartz, feldspar and biotite matrix of 1 cm grain size. Feldspar is typically weathered white and commonly contains small inclusions of biotite; some crystals are compositionally zoned. Quartz anhedra are greyish blue and average approximately 20 percent of the matrix, and biotite generally forms approximately 10 to 15 percent. Tourmaline is a locally concentrated accessory mineral. Muscovite is an additional phase in the northeast corner of the granite (Dickson, 1974).

The granite is massive in most places, but a primary flow foliation is present near its northeastern contact with the Gander Group; the foliation is best seen in the exposures on the shoreline at the east end of Gander Lake. The flow foliation is defined by feldspar megacrysts and elongate metasedimentary xenoliths, most likely derived from the Gander Group (Plate 9). It trends approximately eastward and is steeply dipping in one locality where it can be seen in the third dimension.

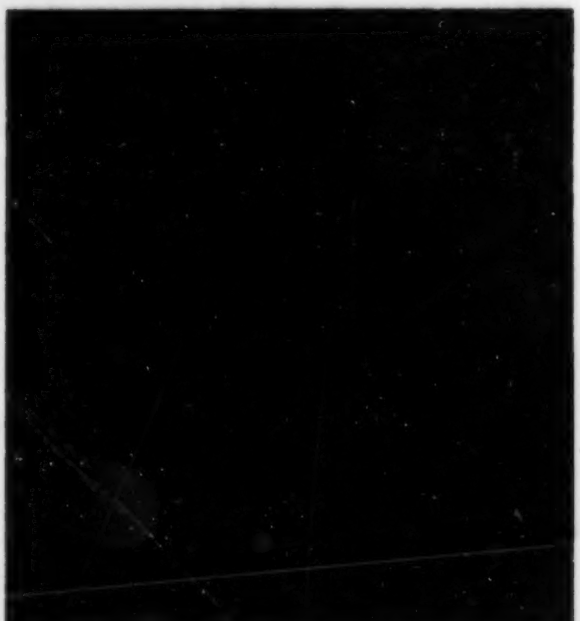


Plate 9. *Elongate metasedimentary xenolith in the Gander Lake Granite (Unit 11), aligned parallel to the magmatic-flow foliation defined by feldspars. Note compass for scale near bottom left corner.*

Approximately 2 km north of the eastern end of Rodney Pond, an exposure of a medium-grained variety of the Gander Lake Granite (subunit 11a) occurs. This granite contains quartz, feldspar and biotite and, although the average grain size is only 3 mm, disseminated megacrysts, up to 3 cm long, form up to 10 percent of the rock. There is only one exposure of this medium-grained granite, but the predominance of the rock type in nearby boulders suggests a fairly substantial outcrop area.

The relationship of subunit 11a to the main, coarse-grained granite is uncertain. Elsewhere, however, medium-grained varieties of the granite have been found both as dykes and as xenoliths. Leucocratic, equigranular granite, with a grain size up to 3 mm, intrudes the megacrystic granite at two localities; at one of these, the dyke margins are overgrown by small megacrysts. In the boulder fields south of Second Burnt Pond, megacrystic granite contains medium-grained granite inclusions, which have rounded margins and contain megacrysts.

The proportion of metasedimentary xenoliths within the granite varies from less than 10 percent to about 70 percent; in particular, there is a noticeable lack of xenoliths close to the granite margin. Contacts between xenoliths and granite are typically very sharp (Plate 10), implying that the country rocks were relatively cool during intrusion and that there was little assimilation of metasedimentary material.

The Gander Lake Granite is cut by a few tourmaline-bearing pegmatite dykes, generally less than 2 m wide, and locally by numerous, thin, quartz–epidote veins. Tourmaline veins, 2 to 4 cm wide, coat joints along the Trans-Canada Highway and are associated with disseminated pyrite. Dickson (1974) reported a number of fluorite-bearing pegmatite boulders in the same area and interpreted them to be locally derived.

Petrography

The granite is composed predominantly of quartz (30 percent), feldspar (60 percent), biotite (up to 5 percent) and muscovite (up to 5 percent). Accessory minerals include tourmaline, apatite and zircon; epidote occurs as an alteration product of feldspar, and biotite is retrogressed to chlorite.

Microcline megacrysts are perthitic and contain inclusions of quartz and plagioclase; in a few cases, the quartz

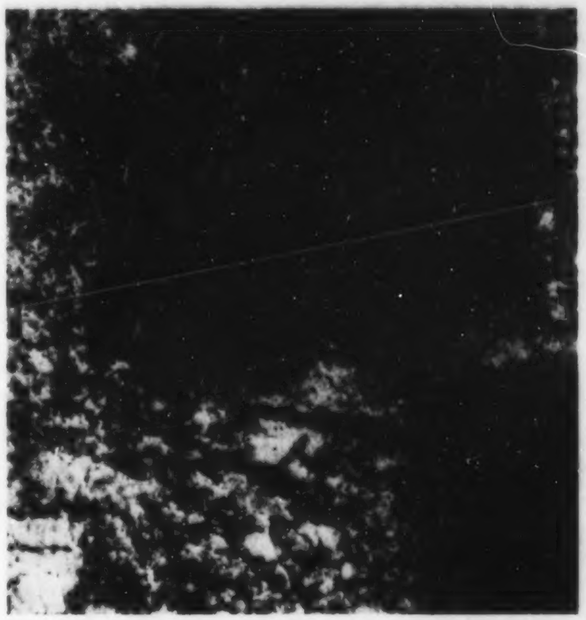


Plate 10. *Angular xenolith in the Gander Lake Granite. Note the sharp contact.*

inclusions are arranged parallel to crystal faces near the edges of the megacrysts. Twinning is patchy and, in most crystals, is strained. Patchy hematization is common. Microcline also occurs in the matrix and small crystals form inclusions in quartz. Large plagioclase grains contain quartz and fine-grained plagioclase inclusions and are concentrically zoned; the inner parts are variously hematized and sericitized.

At the muscovite-rich margin of the granite, south of Rodney Pond, a heterogeneous foliation is defined by trails of pyrite and most of the muscovite is unaligned. Locally, however, the muscovite has been cataclastically reduced to a fine grain size, and together with ribbon quartz, wraps around porphyroclasts of plagioclase, which do not appear to have been significantly affected by the deformation.

In the medium-grained phase of the granite (subunit 11a), north of the east end of Rodney Pond, plagioclase is strongly hematized and sericitized and minor epidote is also present as a feldspar alteration product. Biotite is partially retrogressed to chlorite and the granite is cut by thin epidote and chlorite veins.

GEOCHRONOLOGY

Two new $^{40}Ar/^{39}Ar$ ages have been determined, one on muscovite from the Wing Pond Shear Zone and the other on hornblende from the aureole of the Hunts Ponds Granite. The determinations were done by D. Lux at the University of Maine at Orono, using the method described by O'Neill and Lux (1989). The analytical data are presented in Table 2 and the spectra are illustrated in Figure 3.

WING POND SHEAR ZONE–MUSCOVITE

Results

An $^{40}Ar/^{39}Ar$ age spectrum was determined on a muscovite concentrate from coarse-grained phyllonitic schist

Table 2. $^{40}Ar/^{39}Ar$ analytical data on muscovite from the Wing Pond Shear Zone (ON87-960) and hornblende from the aureole of the Hunts Ponds Granite (ON89-149)

Temp °C	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	Moles ^{39}Ar	^{39}Ar % Total	% Ar^{40} Rad	K/Ca	Age (Ma)
		ON87-960					J = .006779	
670	43.64	0.0086	0.0222	186.3	1.6	84.9	56.67	404.4 ± 3.9
770	41.46	0.0050	0.0079	403.3	3.4	94.3	98.90	424.2 ± 3.9
850	40.04	0.0024	0.0028	983.6	8.4	97.9	201.80	425.1 ± 4.4
900	40.08	0.0013	0.0016	1891.4	16.2	98.8	388.24	428.9 ± 4.1
950	39.95	0.0022	0.0013	1854.1	15.8	99.0	219.43	428.5 ± 3.9
1020	39.91	0.0027	0.0011	1826.1	15.6	99.1	178.66	428.6 ± 3.9
1100	40.03	0.0041	0.0012	1610.5	13.8	99.1	118.82	429.5 ± 3.9
FUSE	39.86	0.0083	0.0008	2952.2	25.2	99.3	59.33	429.0 ± 3.9
TOTAL				11707.5	100.0			428.0 ± 4.0
PLATEAU AGE								428.9 ± 2.8

Temp °C	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	Moles ^{39}Ar	^{39}Ar % Total	% Ar^{40} Rad	K/Ca	Age (Ma)
		ON89-149					J = .006767	
720	921.33	16.580	3.0295	3.5	0.5	3.0	0.029	311.7 ± 251.2
800	565.66	15.250	1.8615	4.4	0.6	3.0	0.032	197.3 ± 148.5
870	250.08	12.379	0.7565	8.1	1.1	11.0	0.039	311.4 ± 23.2
920	126.65	11.705	0.3322	11.3	1.5	23.3	0.042	330.7 ± 28.9
980	64.86	13.314	0.1193	14.6	2.0	47.4	0.036	344.0 ± 8.4
1030	56.61	13.720	0.1015	11.7	1.6	49.1	0.035	313.8 ± 23.0
1070	42.99	18.889	0.0392	18.5	2.5	76.8	0.026	368.5 ± 8.5
1120	37.88	21.712	0.0179	75.2	10.2	91.0	0.022	383.4 ± 6.4
1090	36.70	21.257	0.0127	200.0	27.2	94.8	0.023	386.7 ± 3.8
1200	36.54	21.231	0.0116	175.6	23.9	95.6	0.023	388.1 ± 3.7
1230	36.69	21.194	0.0125	124.4	16.9	94.9	0.023	387.1 ± 4.3
FUSE	37.29	20.988	0.0137	87.0	11.9	94.0	0.023	389.3 ± 4.3
TOTAL				734.4	100.0			381.4 ± 7.3
PLATEAU AGE								387.8 ± 4.3

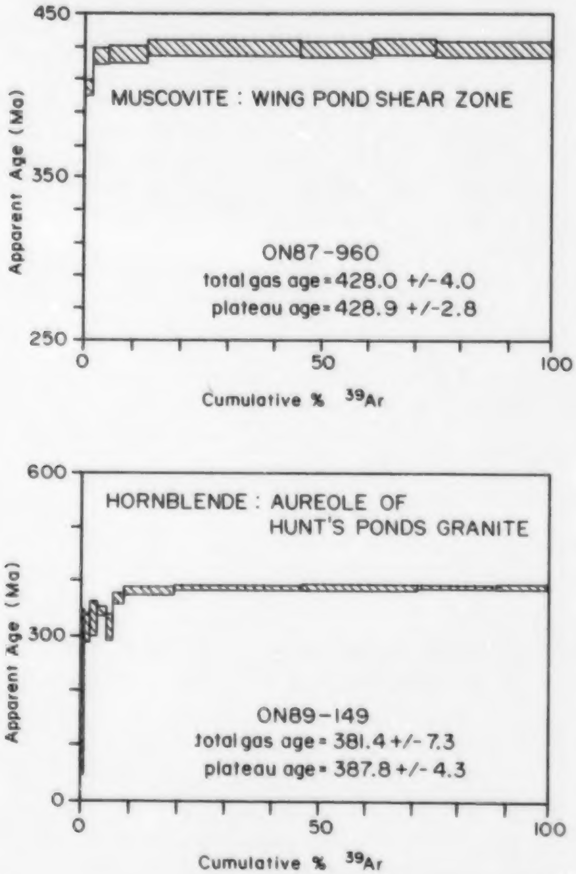


Figure 3. *$^{40}Ar/^{39}Ar$ age spectra for samples from the Jonathan's Pond Formation (Unit 3) in the Wing Pond Shear Zone and the Hunts Ponds Granite aureole.*

of Unit 3 (ON-87-960), located at the north end of Wing Pond (NTS 2E/1; UTM 711500E, 5434700N). The spectrum shows a very well-defined plateau with an age of 428.9 ± 2.8 Ma, which is the same as the total-gas age within error.

Discussion

Muscovite is the principal mineral defining the high-strain fabric in phyllonite of the Wing Pond Shear Zone. Textural relationships indicate that the muscovite has not undergone any extensive recrystallization after the high-strain event and the $^{40}Ar/^{39}Ar$ spectrum also indicates no significant resetting after equilibration at 429 Ma. This implies that rocks of the shear zone were uplifted during the high-strain deformation and were unaffected by the subsequent granite-related regional metamorphism that produced Devonian cooling ages elsewhere in the Gander Group (O'Neill and Lux, 1989; *this report*). Evidence for vertical as well as lateral motion on the shear zone has already been presented.

HUNTS PONDS GRANITE AUREOLE–HORNBLENDE

Results

An $^{40}Ar/^{39}Ar$ spectrum was determined on hornblende concentrated from an amphibolite in Unit 3 (0N-89-149). The amphibolite is within the andalusite zone of the Hunts Ponds Granite aureole on the southern shore of Gander Lake (UTM 663250E, 5420500N). The spectrum exhibits a well-defined plateau with an age of 387.8 ± 4.3 Ma and a total gas age of 381.4 ± 7.3 Ma.

Discussion

The hornblende cooling age of 388 Ma is similar to the muscovite and biotite cooling ages from the Ocean Pond area to the north (O'Neill and Lux, 1989). The Hunts Ponds and Ocean Pond granites are compositionally similar and both contain schistose rocks in their aureoles. Thus, an extensive belt of rocks in the western part of the Gander Zone cooled through greenschist-facies temperatures in the Devonian, somewhat later than Silurian cooling in the Davidsville Group to the west or the Wing Pond Shear Zone to the east.

ECONOMIC GEOLOGY

With the exception of early attempts by government surveys to prove economic reserves of chromite (Snelgrove, 1933), all mineral exploration in the area has been done by private industry. The following history of mineral exploration not only provides a review of past work, but also highlights those parts of the area that are perceived to have the greatest potential; in most cases, attention has been focussed on the Gander River Complex and adjacent rocks, which have been seen as prospective for a variety of commodities. The results of the industry surveys are supplemented by observations of mineralization in the Gander Group that have been made during the present mapping program; the mineral potential of this unit has not been considered attractive by most companies so it has received very limited attention. Finally, non-metallic mineral resources in the area are reviewed; these have been exploited in the past, but their significance has changed in recent years as economic conditions have changed and as demand for new products has been identified.

HISTORY OF MINERAL EXPLORATION

Disposition of Mineral Rights, Concession System

Most of the map area, west of the eastern end of Gander Lake, was a part of the Newfoundland and Labrador Corporation (NALCO) concession that was granted in 1951

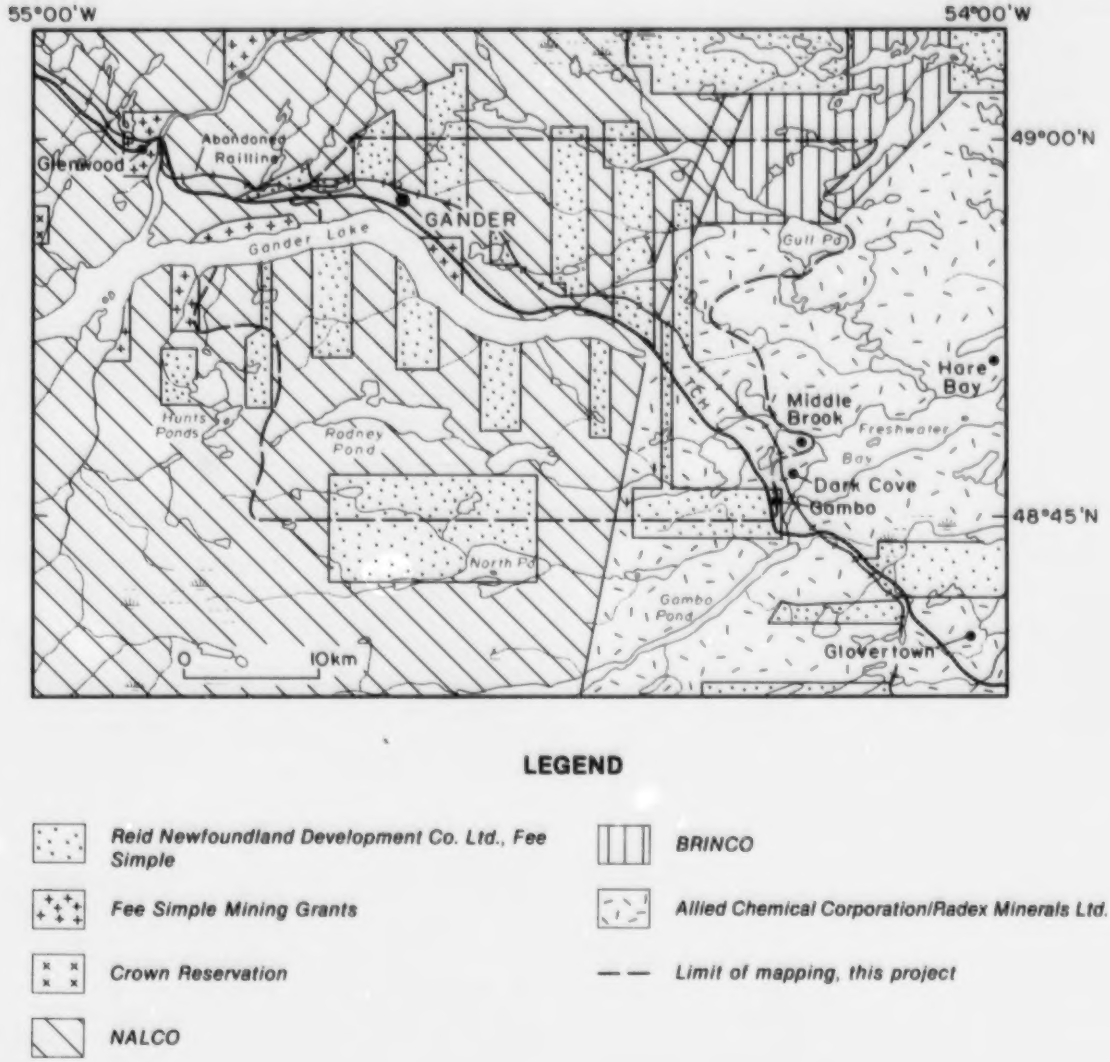


Figure 4. *Disposition of mineral rights in the area around Gander Lake, September 1973 (Newfoundland Department of Mines and Energy, 1973).*

and existed largely intact until 1974 (Figure 4). During this period, mineral rights in the northeast of the area around Home and Wing ponds were held by British Newfoundland Corporation (BRINCO) and in the southeast by Allied Chemical Corporation and Radex Minerals Limited. Substantial areas were excluded from these concessions because of previous Fee Simple Grants, principally to Reid Newfoundland Development Company Limited.

Newfoundland and Labrador Corporation (NALCO)

NALCO had option agreements, which included parts of the map area, with McIntyre Porcupine Mines Limited in the 1960's (Kohlsmith, 1988a) and with other companies (see below) in the 70's and 80's. The only exploration that was conducted directly in the area by NALCO during this time took place in 1954 when a field party investigated the shores of Gander Lake and the region immediately to the south (Wall, 1954).

The work consisted of bedrock mapping and ground magnetometer surveys. Mapping was done along both shores of Gander Lake from west of the Gander River Complex to the east end of the lake. Traverses were made across the country surrounding Hunts Ponds, Gillinghams Pond (Middle Brook Pond), Rodney Pond and Second Burnt Pond. Detailed work was done on individual magnetometer anomalies and reported separately, but these reports are no longer available.

Results were not encouraging. Mineralization was encountered at Hunts Ponds, where poor-quality asbestos and small amounts of disseminated chalcopyrite were reported from amphibolite, presumably forming a part of the Gander River Complex (Unit 1). Elsewhere, a few traces of chalcopyrite were recorded from quartz veins on Gander Lake, but the unit was not specified; the general observation was made that the numerous quartz veins that cut metasedimentary rocks in the area show few signs of mineralization.

No further work was done by NALCO in the area. However, when other parts of the concession were returned to the Crown in the late 1970's and early 1980's, the part of the concession underlain by the Gander River Complex (Unit 1) around Gillinghams Pond and Hunts Ponds was retained because of interest shown by other companies and consequent option agreements.

International Mogul Mines Limited

In 1973, under option agreements with NALCO and Reid Newfoundland Company Limited (Figure 5), International Mogul Mines Limited commissioned an airborne EM and magnetic survey by Kenting Earth Sciences Limited (Rockel, 1973) in the area underlain by the Gander River Complex, from Gander Lake northeast to Ragged Harbour.

In the following year, thirty-two grids were established, including some in or close to the present map area in the vicinity of Rat Pond and Twin Ponds. Work consisted of magnetic and EM ground surveys (Zurowski, 1974b), geological mapping, prospecting, and soil and silt geochemistry (Zurowski, 1974a). Massive pyrite containing disseminated chalcopyrite was noted in deformed tuffaceous rocks at the north end of Rat Pond, and sphalerite, chalcopyrite and galena were found in a large exposure of quartz-feldspar porphyry (Blackwood, 1982), southeast of Rat Pond (MODS 002D/15/Cu 002; Stapleton and Parsons, 1991). Copper, lead, zinc and silver mineralization was recorded from the Twin Ponds area and was also found in felsic rocks of the Gander River Complex (Unit 1).

The various airborne and ground surveys were followed up by diamond drilling during 1975 and 1976 (Zurowski, 1976, 1977). Seven of the holes drilled in 1975, totalling 2,503 ft (765 m), tested EM conductors within NTS 2D/15 at the margin of the present map area (Zurowski, 1976). All of these were drilled southeastward into a series of *en échelon* conductors, five just south of the Trans-Canada Highway at Twin Ponds and two just to the north at Rat Pond.

The rocks intersected in the five holes at Twin Ponds were argillaceous tuffs and graphitic argillites, as well as minor greywackes, felsic volcanic rocks and ultramafic rocks. Massive and disseminated pyrite was encountered in association with the graphitic argillites, but the only indication of base-metal mineralization was a minor amount of sphalerite in felsic pyroclastic rocks. Assays for precious metals were negative. The two holes at Rat Pond were drilled into quartz-feldspar porphyry, similar to rocks previously found to be mineralized in outcrop, and they encountered mainly fragmental felsic rocks, some of which contained disseminated sulphides, including minor sphalerite.

All drilling in 1976 was north of the Gander area and after that the company did no further work under the option agreements.

Hudson's Bay Oil and Gas Company Limited

Following reconnaissance surveys in several parts of NALCO Lot 2 by Dean (1978b), Hudson Bay Oil and Gas Company Limited optioned ground underlain by the Gander River Complex and adjacent rocks from the south shore of Gander Lake southward to beyond Caribou Lake (Figure 6); some of the subsequent work was also done on Reid Lot 75 because of uncertainty concerning the disposition of mineral rights (Fenton, 1981a). The principal targets mentioned in the recommendation and applicable to the Gander area were syngenetic base-metal deposits in volcanic rocks and base-metal, tin and tungsten mineralization related to granite intrusions.

It was suggested in the report of reconnaissance work that an airborne EM and magnetic survey be flown across the optioned ground and this was done in April 1979 providing a total of 1015 line-km of data and identifying nine anomalous EM conductors (Aerodat Ltd., 1979a). A supplementary report was produced on Reid Lot 75 (Aerodat Ltd., 1979b), which lies just west of Hunts Ponds outside the present map area (Figure 6), but contains an anomaly that trends northeast toward the shore of Gander Lake, near the mouth of Richards Brook; geological work on this anomaly was described by Fenton (1981a).

Two airborne EM anomalies were identified and investigated during 1979 within the present area of mapping (Fenton, 1980). These were designated the Casterbridge and Coggan zones (Figure 7). The conductor axis of the Casterbridge Zone lies along Richards Brook, due west of Gillinghams Pond, and the two conductor axes of the Coggan Zone are about 200 m and 400 m to the east of the Casterbridge Zone, respectively. Both zones are underlain by rocks of the Gander River Complex and the Weir's Pond Formation (Units 1 and 7), although the Coggan Zone appears to be very close to the boundary between these rocks and the Jonathan's Pond Formation (Unit 3) (Fenton, 1981b). The Casterbridge Zone consists of a bedrock conductor up to 10 m wide with a strike length of about 700 m; soil geochemistry produced no anomalous results, but two samples of float gave slightly elevated values of base metals and silver. The Coggan Zone is part of a much more extensive system of airborne EM anomalies, and ground EM defined two strong responses within the zone. A good ground EM conductor is in part coincident with a magnetic anomaly, and some elevated values of base metals and silver were found in soils across this conductor.

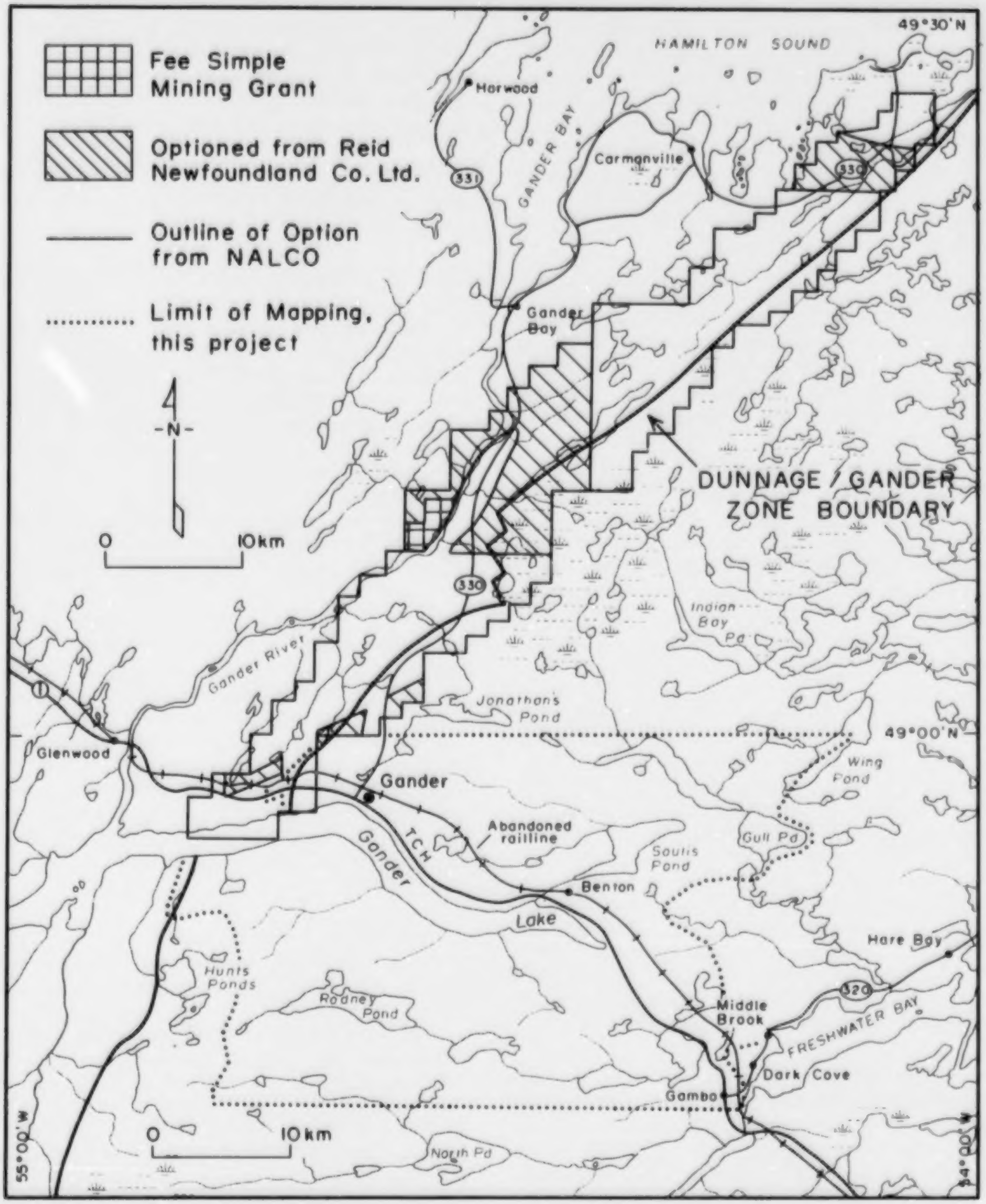


Figure 5. *Mineral rights optioned to International Mogul Mines Limited by NALCO and Reid Newfoundland Company Limited in 1973 and 1974 (Zurowski, 1974a).*

Both the Casterbridge and Coggan zones were further investigated by trenching during 1980 (Fenton, 1981b), but neither was found to contain significant mineralization. The Casterbridge Zone revealed graphitic and pyritic amphibolites on the conductor axis and the conductivity can reasonably be attributed to these rocks. The western conductor in the Coggan Zone lies within a sequence of graphitic sericite–biotite schists and phyllites, which are bounded to the east by ultramafic-derived schist and to the west by quartz-feldspar–sericite–biotite schists; these rock types indicate that the conductor axis is within the Dunnage Zone units of the Gander River Complex and Weir's Pond Formation (Units

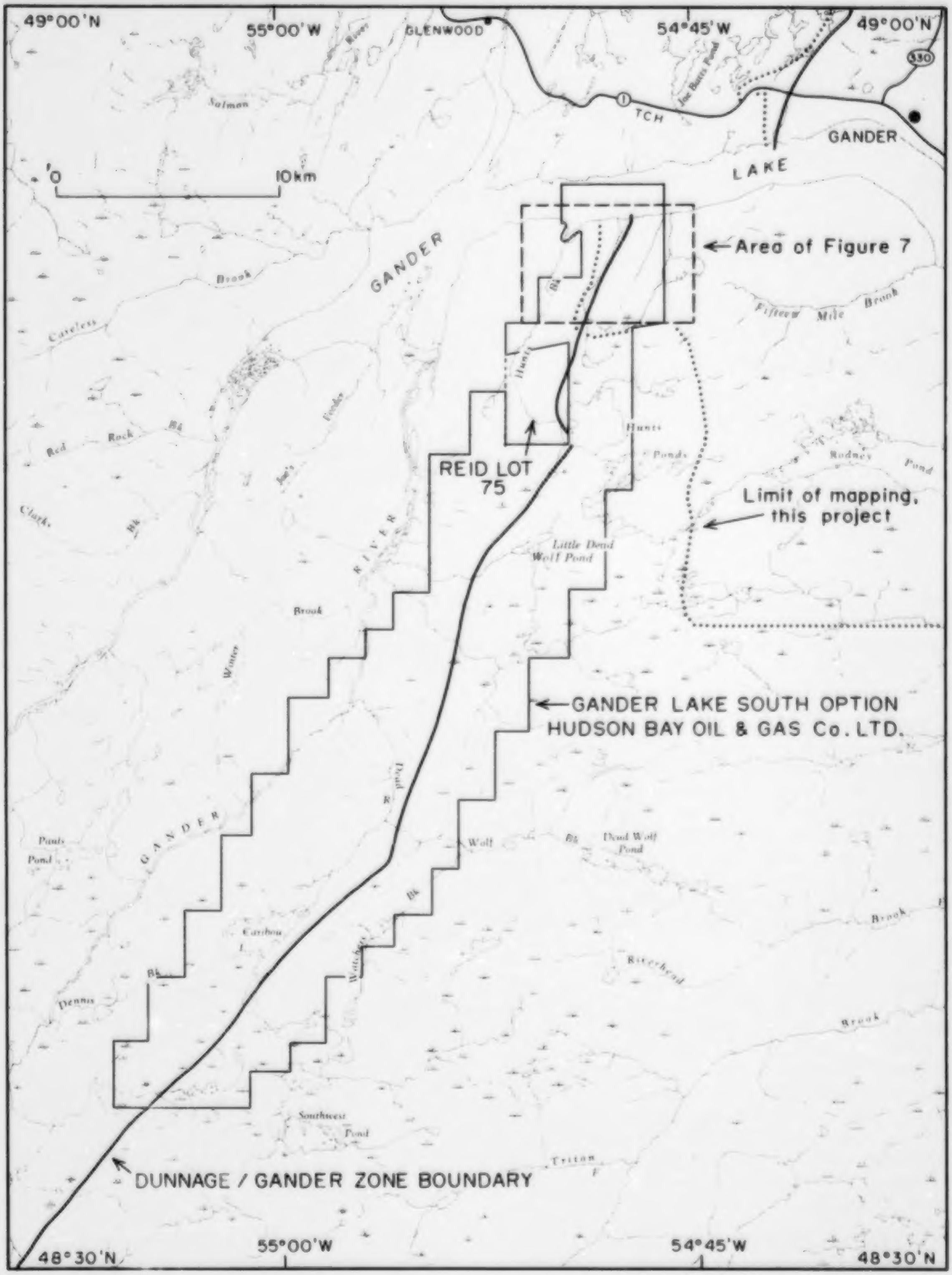


Figure 6. *Mineral rights optioned to Hudson Bay Oil and Gas Company Limited by NALCO, south of Gander Lake, 1979 (Fenton, 1980).*

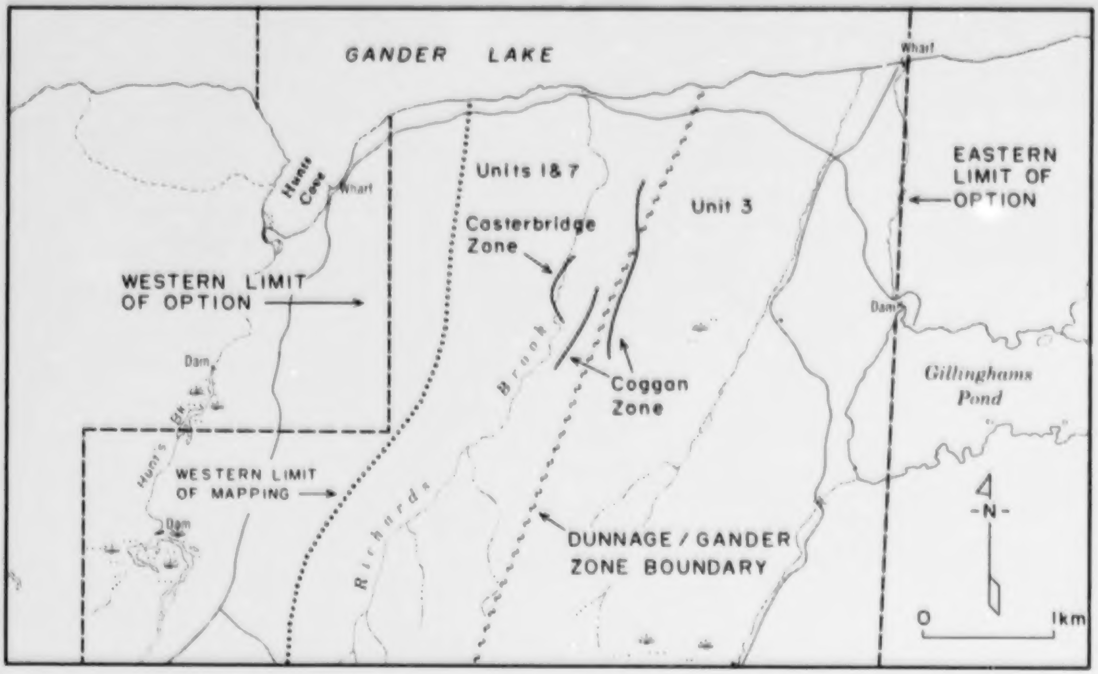


Figure 7. *Location of the Casterbridge and Coggan zones in the northern part of the Gander Lake South Option (Fenton, 1981b).*

1 and 7), although the proximity to the inferred contact with the Jonathan's Pond Formation (Unit 3) may allow for some structural imbrication of this unit too.

CEGB Exploration (Canada) Limited

CEGB Exploration did reconnaissance exploration of a number of areas in insular Newfoundland during the summer of 1985 (Skopik, 1986). The program included 8 man-days of radiometric prospecting and stream-sediment sampling in the area of the Hunts Ponds Granite (Unit 10), on both sides of the Gander River Complex (Unit 1). Within the present map area, they sampled Richards Brook, the brook flowing north out of Gillinghams Pond, and nearby shoreline exposures on Gander Lake.

Results were not encouraging and no further work was recommended. Only two anomalies were identified and neither of these was deemed significant. The first was in an area of almandine-mica schist of the Jonathan's Pond Formation (Unit 3), cut by granite pegmatite dykes. The margin of a pegmatite dyke yielded a maximum of 1700 cps against a background of 500 cps, and one grab sample contained 47.2 ppm leachable U_3O_8. The second anomaly was in graphitic schist of the Weir's Pond Formation (Unit 7) at the mouth of Richards Brook, where spot highs of 1600 cps were recorded against a background of 500 cps.

Lacana Mining Corporation/ Corona Corporation

During the summer of 1987, Lacana Mining Corporation staked a 12-km-long stretch of the Gander River Complex, just south of Gander Lake (Chance, 1988); the claim block approximately coincided with the northern part of the Hudson Bay Oil and Gas Limited option from NALCO (Fenton, 1981b) (Figure 8); the target of the exploration program was gold. Interest had been sparked by reports of gold finds along strike, north of Gander Lake, and in similar rocks associated with the Great Bend Complex to the southwest (Zwicker and Strong, 1986); there were also reports of anomalous gold in tills found just south of Hunts Ponds by Duval International Corporation.

Work within the present map area in 1987 consisted of prospecting and sampling silts and bedrock along Richards Brook and the brook between it and Gillinghams Pond (Chance, 1988). None of the stream sediments contained anomalous values of the fifteen elements analyzed and none of the grab samples had anomalous gold. However, one silt sample at the southwest corner of Hunts Ponds, outside the area, returned a value of 34 ppb gold and four grab samples from within the area had elevated levels of arsenic (Figure 8). These grab samples were from a boulder of siliceous argillite (3100 ppm) and an exposure of graphitic slate (120 ppm) in Richards Brook, a boulder of hematized ultramafic rock (220 ppm) in the next brook to the east, and an *in situ* pyrrhotite-bearing quartz vein (200 ppm) on the shore of Gander Lake.

In 1988, Corona Corporation (as successor to Lacana Mining Corporation) followed up the initial work with a till and soil survey over the entire claim block and limited prospecting and stream-sediment sampling (Dimmell, 1988). Heavy-mineral separates from the till (C horizon) samples

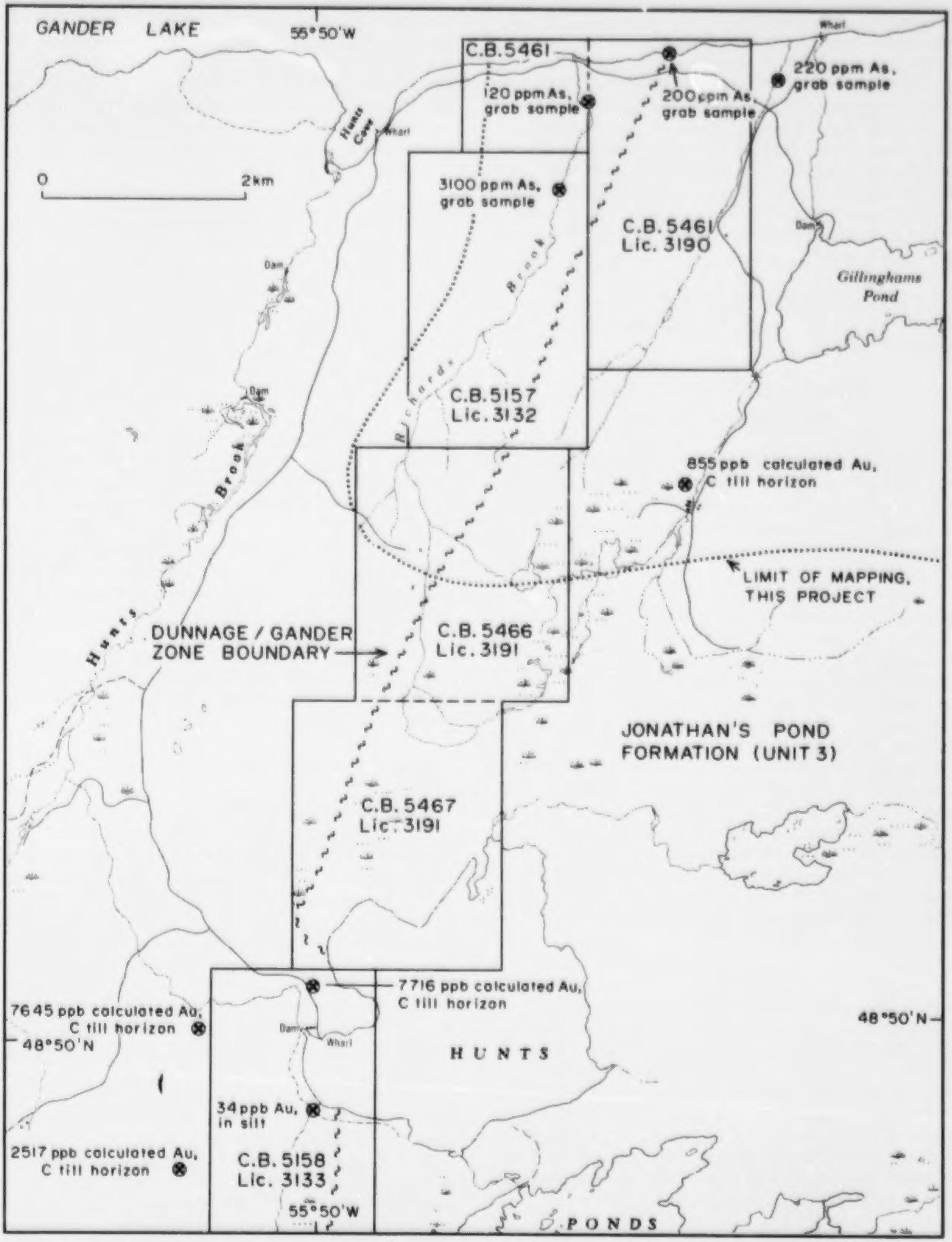


Figure 8. *Northeastern claim blocks staked by Lacana Mining Corporation (Corona Corporation) south of Gander Lake, 1987, showing location of principal mineralized samples (Chance, 1988; Dimmell, 1988).*

indicated significant calculated gold values (up to 7716 ppb) near Hunts Ponds, southwest of the present map area, and a distance to source from abrasion interpretation of at least one kilometre (Figure 8); within the map area, the highest calculated value was 855 ppb in till overlying the Jonathan's Pond Formation (Unit 3), about 2 km southwest of Gillinghams Pond. Soil (B horizon) samples gave only background values for gold and silver and, at best, only weakly anomalous values of arsenic and antimony. Stream-sediment sampling and prospecting were only done southwest of Hunts Ponds and produced some weakly anomalous gold and arsenic values in silts.

It was recommended that claims in the northern part of the claim block (i.e., north of Hunts Ponds) be abandoned (Dimmell, 1988).

Kidd Creek Mines Limited/ Falconbridge Limited

In December 1986, Kidd Creek Mines Limited staked two claim blocks (Licenses 2991 and 3137) north of Gander Lake, in an area straddling the Gander River Complex (Unit 1) (Figure 9). The principal target was gold, although the potential for silver and base metals was also evaluated.

The northern claim block (License 2991) only just overlapped the present map area, where the Gander River Complex outcrops north of the Trans-Canada Highway, and the area of overlap was dropped in the first year of exploration when the license was reduced (Kohlsmith, 1988a). During this first year (1987), exploration consisted of till prospecting and limited bedrock prospecting. A total of nineteen till samples yielded four with elevated gold values in heavy-mineral separates, and anomalous values of gold, nickel, copper and zinc were reported from whole-till samples. Rock samples from quartz-feldspar porphyry southeast of Rat Pond yielded 0.12 percent copper and 0.23 percent zinc (MODS 002D/15/Cu 002; note that this showing and related showings are referred to by Falconbridge geologists as the Twin Ponds showing, whereas the Twin Ponds showings on MODS are all on or south of the disused railway on Falconbridge License 3137; Stapleton and Parsons, 1991).

Further work on the reduced area of License 2991 was done in 1989, entirely outside the present map area. The work consisted of geological mapping, prospecting, lithogeochemical sampling, and VLF and IP surveys. The best recorded mineralization remains a grade of 1 percent zinc over 3 m reported by Riocanex (in Kohlsmith, 1988a, 1989) in Hole 75-4, which was drilled by International Mogul Mines, southeast of Rat Pond (Zurowski, 1976) (Figure 9); the host rock is quartz-feldspar porphyry (Blackwood, 1982) or fragmental rhyolite (Kohlsmith, 1989), forming a part of the Gander River Complex (Unit 1).

The southern claim block (License 3137) extended south to Gander Lake and its eastern portion overlapped the present area of mapping; the claim block included Twin Ponds showings 1, 2 and 4 (MODS 002D/15/po 001, pyr 001, pyr 003; Stapleton and Parsons, 1991). Work during 1987 consisted of till sampling ('BT' horizon) and prospecting (Kohlsmith, 1988b). Four out of twenty-two sampling sites gave elevated gold values in heavy-mineral separates, and one site had an elevated value in whole-till; one site also produced a single, small grain of visible gold.

South Coast Resources Inc./ Long Range Resources Limited

A claim block was staked in the name of South Coast Resources Inc. during 1987 on the north shore of Gander Lake, immediately south of Gander International Airport (Dearin, 1989; Figure 10). In the same year, preliminary prospecting, and bedrock and till sampling were done. The entire claim block is underlain by the Jonathan's Pond Formation (Unit 3) and, within the claim block, quartz veining and intense silicification and brecciation of the metasediments were reported; these were attributed to an epithermal hot spring system. Gold and silver values were reported as being anomalous in some rock and till samples, including one silver assay from a quartz vein of 46.4 ppm.

During 1990, geological mapping and rock and heavy-mineral stream sampling were done (Dearin, 1991). The silicified breccia zone, 10 to 50 m wide, was traced for 1800 m. Up to 10 percent disseminated pyrite and pyrrhotite mineralization were found where the silicification affects an adjacent gabbro intrusion (not separated on the 1:50 000 map); elsewhere less than 1 percent disseminated pyrite is present in some of the quartz veins and metasedimentary rocks.

Noranda Exploration Company Limited

The Tower property, about 3 km east of Gander Lake, was staked for its gold potential in November 1988 (Figures 10 and 11), following the release of lake-sediment data by the Newfoundland Department of Mines and Energy (Davenport *et al.*, 1988). The data showed a multielement lake-sediment anomaly that coincides with an east–west-trending magnetic feature. The geochemical anomaly is characterized by very high antimony and arsenic and elevated gold values. Most of the property is underlain by laminated black to green pelite and sandstone of the Indian Bay Big Pond Formation (Unit 6), but psammites and pelites of the Jonathan's Pond Formation occur in the southeastern portion.

Lake-sediment and soil-geochemical surveys defined the anomaly as occurring along the southeast contact of the Indian Bay Big Pond Formation with the Jonathan's Pond Formation (Unit 3) (Graves, 1990). It extends for about 3 km northeast from the abandoned railway, which marks the southwest boundary of the property. The lake-sediment survey, which extended beyond the property boundary to the south shore of Soulis Pond, returned anomalous levels of arsenic, antimony, lead and gold. Prospecting identified several alteration zones with gold values up to 1 g/t (Figure 11). The

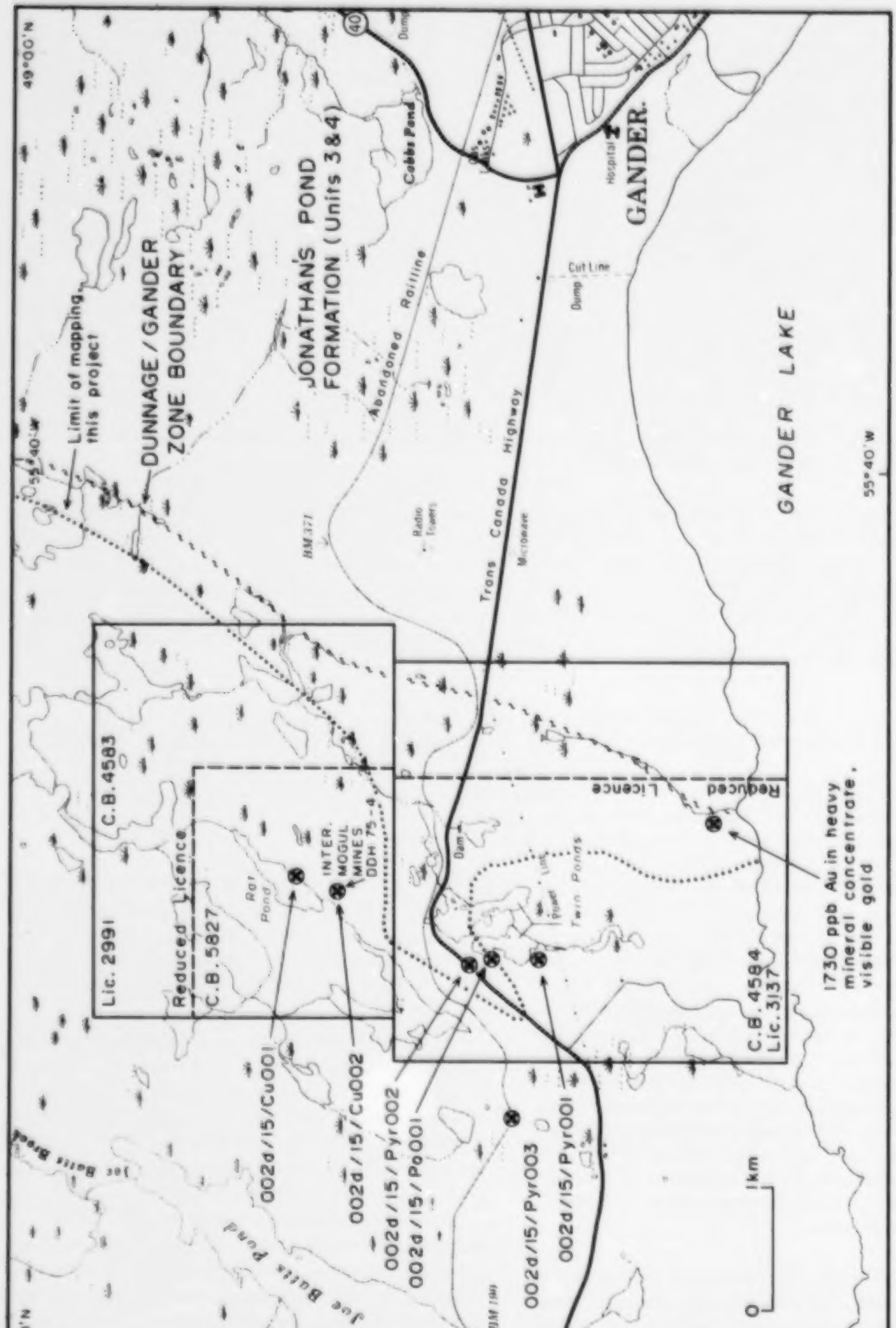


Figure 9. *Claim blocks staked by Kidd Creek Mines Limited (Falconbridge Limited) north of Gander Lake, 1986, showing location of mineralization reported in MODS and assessment files (Zurowski, 1977; Kohlsmith, 1988a, b, 1989; Stapleton and Parsons, 1991).*

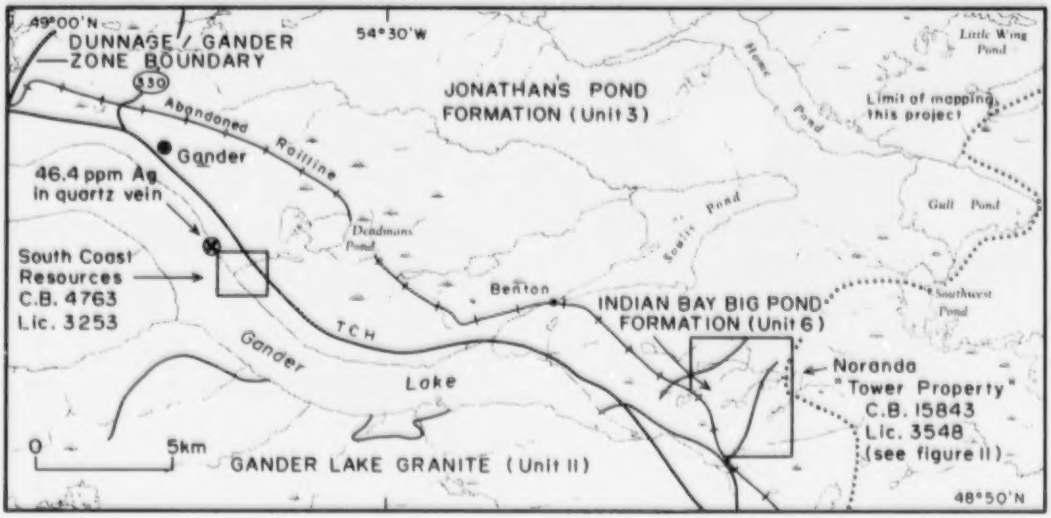


Figure 10. *Claim blocks staked by South Coast Resources Incorporated and Noranda Exploration Company Limited in 1987 and 1988, respectively (Dearin, 1989; Graves, 1990).*

mineralization occurs in strongly foliated metasedimentary rocks containing disseminated pyrite and arsenopyrite, together with minor chalcopyrite and stibnite. Assay reports also list two rock samples having 2,610 and 2,680 ppb (2.61 and 2.68 g/t) gold respectively, but no locations are given.

NEW MINERAL OCCURRENCES

New mineral occurrences found during mapping are listed in Table 3 and their locations are shown on the map.

The most significant new occurrence is in quartz-rich sandstone of the Jonathan's Pond Formation (Unit 3), in a roadcut on the Trans-Canada Highway, east of the Benton junction. The rusty-weathering mineralized zone is approximately 7 m wide and locally has been extensively sericitized. It is characterized by both disseminated and vein pyrite and galena. The mineralization locally follows the solution seam cleavage and therefore appears to postdate development of the main tectonic foliation. A chip sample (Sample 89-213, Table 3) yielded 41 ppb gold, 5.2 ppm silver and 2.6 percent lead. At the eastern edge of the occurrence, a galena-rich vein, up to 2 cm thick (Sample 89-217), yielded 34 ppb gold, 28 ppm silver, 41 ppm antimony and 15 percent lead. Although the mineralized zone could not be traced away from the highway because of lack of exposure, it appears likely that it trends parallel to the regional strike. The occurrence is within the aureole of the Gander Lake Granite (Unit 11), but it is not known if the granite or associated fluids caused the mineralization.

Quartz veins are ubiquitous in the Gander Group, north of Gander Lake, and vein networks are common. Many sampled quartz veins have yielded anomalous gold values (Table 3), the highest being 140 ppb from a pyritiferous vein. Anomalous arsenic, silver, antimony, tungsten and molybdenum also occur. Most of the sampled veins are less than 0.5 m thick, but some are as much as 6 m thick. They are generally subparallel to the regional foliation and were probably generated during regional metamorphism, which was dominantly in the greenschist facies north of Gander Lake. The anomalous metal concentrations may have been leached from the host sedimentary rocks by metamorphic fluids.

OTHER MINERAL RESOURCES

Dimension Stone

(contributed by J. Meyer)

In the 1890's, granite blocks were quarried 8.5 km southeast of the town of Benton, on the northeast margin of the Gander Lake Granite. The blocks were extracted by the Reid Newfoundland Company Limited, who used them in the construction of railway bridge abutments.

Carr (1958) reported several small excavations along both sides of the old railway line, one of which lies 30 m southwest of the old railway bed in a small gulley and is presently flooded (UTM 695790E, 5414390N; MODS 002d/16/stn001). There are no signs of recent workings, but there are still at least thirty blocks stacked up adjacent to the railway; these have an average size of 1.5 by 0.5 by 0.5 m. The quarry opening is approximately 15 by 25 m and contains a ledge that is about 6 m long and 2 m high. The granite is coarse-grained, and its colour is dominated by 25 to 30 percent light-pink feldspar, which occurs interstitially and as phenocrysts up to 4 cm in length. Equal amounts of medium-grained grey quartz and white feldspar make up 50 to 60 percent of the stone, with 10 to 15 percent of evenly distributed black biotite.

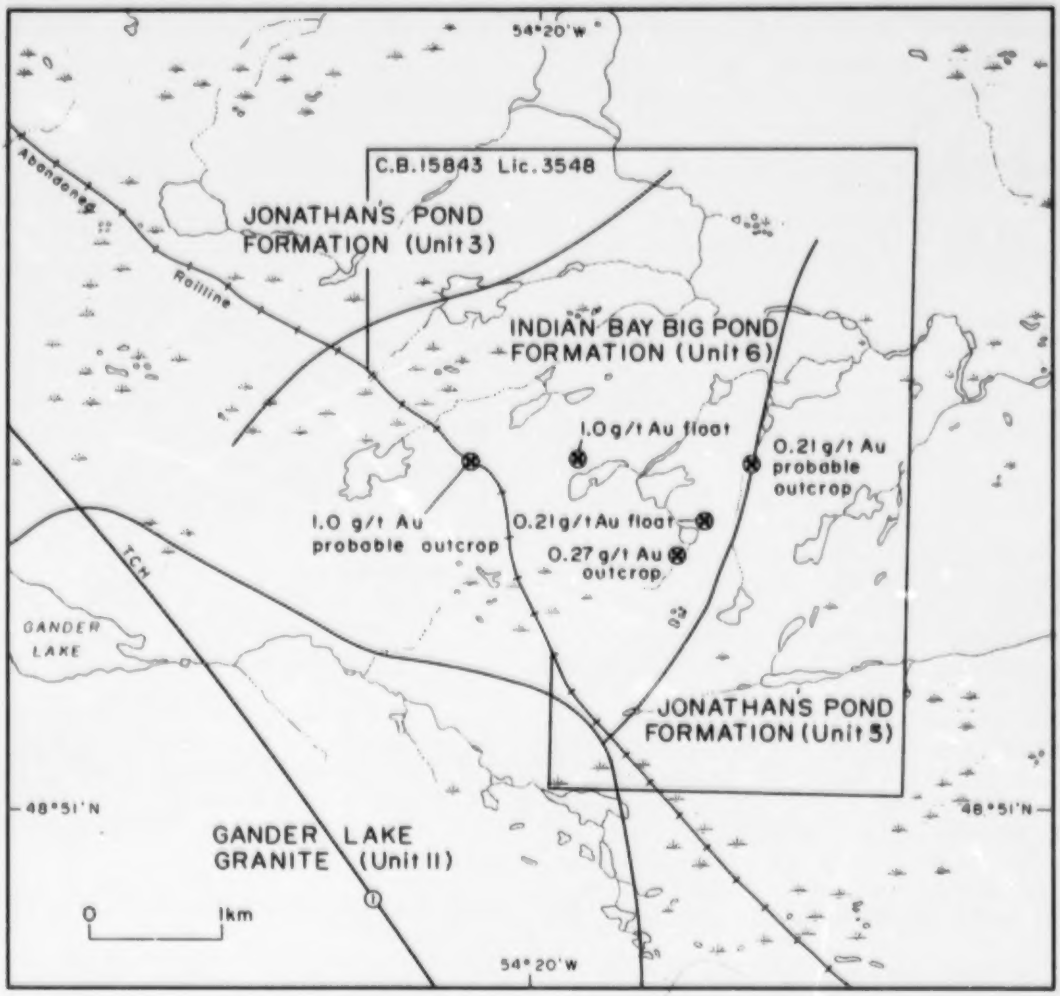


Figure 11. *'Tower Property' of Noranda Exploration Company Limited, 1988, showing location of gold-bearing rock samples (Graves, 1990).*

A quarry exploration licence for this area is presently held by Mr. John Kealey of St. Alban's (as of 1992).

Bedrock Aggregate

Bragg (1989, 1990) has investigated the main units described in this report for their suitability as sources of bedrock aggregate. Metasedimentary rocks of both the Davidsville and Gander groups (Units 3 to 7) are deemed to be generally unsuitable for concrete, but may be used as Classes B and C fill material or Class A material for asphalt. Trondhjemite and gabbro of the Gander River Complex (Unit 1) provide excellent aggregate for all construction purposes, but ultramafic and mafic volcanic rocks are poor to good depending on the degree of alteration and weathering. The Gander Lake Granite (Unit 11) was sampled at the Benton quarry, where it is of excellent quality (Bragg, 1986).

Surficial Aggregate

Initial aggregate-resource assessment was done in the Gander Lake area by Kirby and Ricketts (1983). It was restricted to a corridor along the major transportation routes. Ricketts and McGrath (1990) have subsequently conducted a comprehensive survey of granular aggregate resources through the part of the map area within NTS 2D/15 (see also Ricketts, 1992). No deposits have been identified within the limits of bedrock mapping, but one is located just to the west at Little Harbour. It consists of till and is of substantial size, but low quality; it has been exploited for fill in the Gander area.

In the part of the map area within NTS 2D/16, the reconnaissance work along transportation routes has been supplemented by more detailed mapping around Butts Pond (Environmental Geology Section, 1983 a,b, Maps 2D/16 to

Table 3. Assay results of grab and chip samples from new mineral occurrences found in the map area

Sample number	Grid ref.	Map area	Au ppb	Ag ppm	As ppm	Sb ppm	W ppm	Mo ppm	Pb %	Comments
89-09	668880E 5423920N	2D/15	-	-	49.0	-	2.0	-	-	Pyritiferous sandstone
89-16	668280E 5426120N	2D/15	-	-	22.0	0.8	-	-	-	Pyrite-rich altered ultramafic
89-33	675100E 5423800N	2D/15	140.0	-	3.0	-	10.0	-	-	Pyrite-rich quartz vein (gossan)
89-37	682400E 5419160N	2D/15	92.0	4.7	3.5	0.8	-	-	-	Pyrite-rich quartz vein (gossan)
89-42	685950E 5421500N	2D/16	18.0	-	26.0	1.0	-	46.0	-	Pyrite-rich quartz vein (gossan)
89-58	676520E 5421300N	2D/15	3.0	-	10.0	-	4.5	-	-	Rusty sandstone
89-129	704200E 5429440N	2D/16	43.0	-	48.0	39	5.5	2.0	-	Pyritiferous silicified zones in sandstone
89-144	695840E 5421640N	2D/16	4.7	-	13.0	3.8	4.8	-	-	Rusty quartz veins/sandstone
89-158	662280E 5420380N	2D/15	29.0	-	3.9	-	-	37.0	-	Mafic rock
89-161	662100E 5420320N	2D/15	-	-	51.0	-	-	-	-	Talc-carbonate rock
89-205	687920E 5418180N	2D/16	-	7.5	-	-	3.2	9.0	-	Pyritiferous quartz vein
89-206	688440E 5418020N	2D/16	2.0	-	14.0	1.2	8.7	-	-	Pyritiferous quartz vein
89-210	690500E 5416760N	2D/16	4.1	-	36.0	-	228.0	36.0	-	Pyritiferous quartz vein
89-213	690940E 5416650N	2D/16	41.0	5.2	13.0	6.5	3.8	12.0	2.6	Sericite and silica-rich alteration in psammite; containing pyrite and galena
89-217	690940E 5416650N	2D/16	34.0	28.0	7.0	41.2	2.4	38.0	15	Galena-rich vein
89-218	690940E 5416650N	2D/16	13.0	-	164.0	1.8	5.7	-	-	Rusty zone in psammite
89-223	691980E 5416050N	2D/16	4.5	-	10.0	-	10.0	6.0	-	Pyrite-rich quartz vein

22) and Gambo (Kirby, 1984). A large glaciofluvial outwash deposit between Butts Pond and the east end of Gander Lake currently supplies good-quality granular aggregate for the Gander area.

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Note: Geological Survey Branch file numbers are included in square brackets.

MAPS NOT FILMED

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